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Forthcoming Events.

JANUARY 8.

Institute of British Foundrymen (London Branch):—Ordinary meeting in London. "Non-Ferrous Casting Alloys: Aristocrats and Commoners."

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Introspective 1925.

Never since THE FOUNDRY TRADE JOURNAL was published weekly, that is four years ago this week, have we ever felt so optimistic of general trade conditions, which, after all, is the only condition which can influence the foundry industry considered as a whole. Whilst a few industrial disturbances are now clouding the horizon there is better machinery in existence for their rapid dispersal. Revision of conditions of employment are now being considered in marine engineering, railway, and in our own industry. It is to be hoped that the volume of remunerative business will enable better conditions to be granted. If the demands exceed the conditions generally acceptable, then the ability to compete in the world's markets is restricted; but if the demand is so insistent that the customers will pay very remunerative prices, then the extra cost involved can be met. It should be realised that British foundry wages are regulated by the labour and other conditions in operation in the United States of America, Germany, Belgium, France, Holland, and other countries, and by the demand for British produce in the markets of the world and not by the profits as shown by the dividends of public companies.

The automobile foundries have every prospect of remaining busy for some time. For the home trade there is every prospect of lessened imports, as the new Government proposes to re-impose duties which previously existed under the Safeguarding of Industries Bill. Additionally there is an increasing demand for British cars, and especially motor cycles, in central Europe. The demand for builders' castings is not likely to be less than 1924, and as there is definitely less unemployment amongst foundrymen associated with this industry than there was in 1913, we anticipate an acute shortage, if trade really flourishes.

Textile foundries too are becoming increasingly busy, though there is much leeway to make up. The prospect for marine engineering castings is doubtful, as during the closing weeks of 1924 but few orders for new ships were placed. Railway castings foundries can expect conditions at least equal to 1924, which could not be regarded as being unfavourable. Electrical and general large engineering castings foundries have not been really busy for some two years now and only a great general revival in trade can help them. They are, however, better equipped than ever previously to enter into the world's markets.

The light steel castings industries invariably feel the competition of foreign foundries, yet an examination of the Board of Trade Returns fails to reveal the extent of this. Certainly the classification "Steel Castings" does not include all competitive material. Several manufacturers of light steel castings have gone out of business during the year and if those left in pursue the course adopted by some of making every individual casting contribute its quota to the profit account the industry will continue to gain strength.

The important agricultural implement foundries have not been fully occupied since the war. Their largest market was Russia in pre-war days. Germany has perhaps had better opportunities for studying this market than British works, whilst the Americans have developed cheaper lines of engines on a quantity production basis. Apparently there is not much prospect for increased business in the near future, though a well organised sales campaign in the Colonies and

South America might do much to compensate for the markets which are, temporarily we hope, lost.

This year the Conference of the Institute of British Foundrymen is to be held under the presidency of Mr. John Cameron, of Kirkintilloch, at Glasgow in June. A strong local committee has been working for some time, and the support of the most eminent local leaders of thought, industry and civic administration is assured.

Of indirect interest to foundrymen will be the reconstructed British Empire Exhibition at Wembley and the Shipbuilding and Engineering Exhibition at Olympia. Of the former it is as yet unknown what form or extent the engineering exhibits will assume. We do not think that they will be so numerous as last year.

No International Foundry Congress is to be held this year, but next year one is to be held somewhere in the Eastern States of the United States, and already the American Foundrymen's Association are working out the details. The members of the various European foundry technical associations are to be invited to co-operate. From the letters which the officers of the Institute of British Foundrymen are constantly receiving the Americans still have appreciative memories of their reception in England, and they intend to leave no stone unturned to return in full measure the hospitality received.

Personal.

MR. W. MARRIOTT, traffic manager since 1918 and engineer of the Midland and Great Northern Joint Line retired at the year end.

MR. P. S. HALE has been elected a director of McLean, Harrison & Company, Limited, Suffolk House, Laurence Pountney Hill, London, E.C.4.

MR. C. FINDLAY, formerly Glasgow representative of the Independent Pneumatic Tool Company, 40, Broadway, Westminster, S.W.1, has been appointed district manager of the company.

MR. F. HUDSON, metallurgist and melting manager at the Close Works, Newcastle-on-Tyne, of Sir W. G. Armstrong, Whitworth & Company, Limited, has resigned his position and proposes travelling abroad with the object of studying Continental methods.

MR. H. S. PRIMROSE, metallurgist to Campbell, Gifford & Company, Limited, of 17, Victoria Street, London, S.W.1, is at present instructing the staff of the St. Chamond Works of the Cie des Forges et Aciéries de la Marine et d'Homecourt as to the working of the H.E. process of melting and fabricating stainless iron ingots and their products.

MR. H. FOSTER BAIN, the United States Bureau of Mines director, has sailed for the Argentine to make a study of the possibilities of developing an iron and steel industry in that country. This is being undertaken by Dr. Bain at the specific request of the Argentine Government. The survey will include economic studies as to the feasibility of the enterprise, as well as examinations of the necessary mineral raw materials.

MR. D. B. MORISON, chairman and managing director of Richardsons, Westgarth & Company, Limited, of Hartlepool, Middlesbrough and Sunderland, terminated his long association with that company at the end of 1924. Mr. Morison, who was manager of the Hartlepool Engine Works when they were opened by Thomas Richardson & Sons, became joint managing director when the establishment was merged in Richardsons, Westgarth & Company in 1900, was made sole managing director in 1912 and in 1918 was elected to the chairmanship also. For the past year or so Mr. Morison has been in indifferent health, and he is now wintering in the South of France. He is to be succeeded in the chairmanship by Mr. T. Westgarth, who has also been a director of the company since its formation. Mr. George Clark, who has been a director since 1917, will assume the position of managing director, while Mr. L. D. Wingate, who has been associated with the Hartlepool Engine Works since 1885, and who was made a director of Richardsons, Westgarth & Company in 1922, becomes general manager.

Wills.

CORBETT, D., of Middlesbrough, a partner in firm of Swan Bros., iron merchants	£4,153
SCOTT, ADMIRAL SIR PERCY, chairman of the Kingsbury Engineering Company...	£129,671
COLLINS, C. B., of Devonshire Road, Birkenhead, head of H. B. Collins & Sons, iron merchants, of Birkenhead	£34,561
FITZMAURICE, SIR MAURICE, of Coode, Fitzmaurice, Wilson & Mitchell, for 11 years chief engineer to the London County Council	£94.215

Book Reviews.

Workshop Gauges and Measuring Appliances, by L. Burn, A.M.I.Mech.E. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 5s. net.

This little book is an introductory treatise on the principal measurements required and the instruments used in workshop practice, and has been written primarily for apprentices and students.

The book is divided into eight chapters, and each one of which could usefully form a lesson for foundry students or apprentices. Though the book has in all probability not been written for the foundry at all, it so happens that it contains information which every foundry foreman and manager knows and uses, but he has never learnt the subject methodically. Some he has learnt at school when taking mensuration, some he has picked up in dealing with the pattern-shop, and other portions during his first worry over mechanical testing. The book is well illustrated, and well indexed. It contains 154 pages of matter, and is recommended to teachers of foundry classes as a methodical treatise for covering the ground usually dealt with under the general heading of mensuration.

Physics in Industry, Vol. 11, being lectures delivered before the Institute of Physics by J. W. Mellor, D.Sc.; A. E. Oxley, D.Sc., and C. H. Desch, D.Sc., F.R.S., with a foreword by Sir Chas. A. Parsons, K.C.B. Published by the Oxford University Press, Amen House, London, E.C.4. Price 3s. net.

This volume contains three Papers:—"Application of Physics to the Ceramic Industries"; "The Physicist in the Textile Industries," and "The Physicist in Metallurgy." The last one, by Professor Desch, should be read by all foundrymen. It is alone worth the money charged for the book, but at the same time we believe that the separation of the book into pamphlet form into the industries covered would give it a wider circulation.

The number of people interested in the application of physics to the metallurgical, textile and pottery industries must be exceedingly small.

Dr. Desch, in his Paper, has shown in the clearest possible way, that the modern metallurgist must be also physicist. We do not believe that the Professor would advocate the appointment of a works physicist with a knowledge of metallurgy, except perhaps in the largest of metallurgical concerns, but rather that the works metallurgist must be prepared to specialise in physics in order that he may utilise in his every-day work the results of modern physical research. With this we are in total agreement, because it would seem that the interpretation into practice of much recent research work still remains to be done.

The Refractories Association.

An interesting meeting was held at the Royal Victoria Hotel, Sheffield, on December 18, when Mr. W. H. Tyler, M.Sc., who has recently returned from Burma, gave an interesting outline of the methods operative in that country in the mining and smelting of lead, zinc and silver ores. Particular reference was made to the refractory materials in use, and being new ground the whole subject was of great interest to the members of the Association. At the close of the proceedings Mr. Tyler was most heartily thanked by Mr. Frank Russell, F.G.S., F.E.S., the Chairman and President of the Association.

Foundry Query.

Mixture for Pot Rings.

We are meeting with a difficulty in the mixture of metal satisfactory for casting what are commonly called pot rings, which are used in the annealing furnaces of wire manufacturers. They are subjected to great heat, which causes the rings to curl up and almost melt. We have been using a mixture of No. 3 pig-iron and good class machinery scrap, which is evidently too soft. We should be grateful for any suggestion of a suitable mixture.—Yours, etc.,

"OLD FOUNDRY."

Modern Problems and Developments in Engineering Bronze Founding.*

By Francis W. Rowe, B.Sc., M.I.Brit.F.

It is not the author's intention to deal extensively with modern methods of production in bronze foundry practice, nor with the details of the alloys used, as this phase of foundry work should be quite familiar to most. It is intended, however, to deal with specific problems and possible developments, particularly those which seem, in the author's opinion, to lack the attention they merit.

Those concerned with actual works production are always particularly impressed with the small amount of information available regarding the more commonly used alloys in industry. That

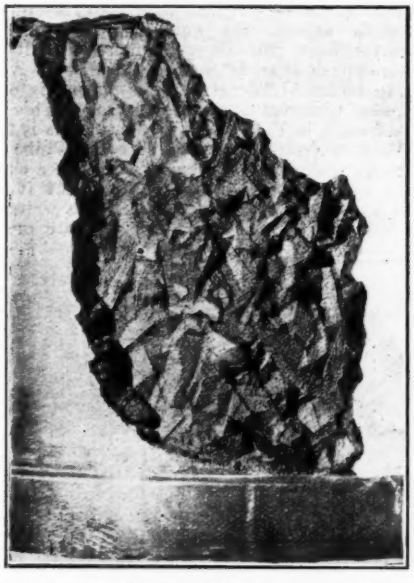


FIG. 1.—AN OXIDISED BUSH, SHOWING INTERGRANULAR FRACTURE.

such information, even of a purely scientific character, should be so meagre and scrappy, is a serious indictment against the academic research worker, especially when one considers the amount of time and money spent annually on non-ferrous research.

It is true that sterling work has been done in the past, but the present tendency is, with a few exceptions, for the academic research worker to devote his time to investigating alloys and alloy systems which do not find any application in industry and, what is more important, probably never will do. The author would be the very last to decry the possibilities and ultimate value of the work done in pure science, but the recent remark " that we are getting too much jam and too little bread " aptly seems to sum up the present situation. The works-metallurgist, whilst realising the urgent need for scientific data on industrial alloys, has not the time to devote to pure research, nor, if he had, would his findings, in the majority of cases, be available for others. To quote but one specific instance of this deficiency—the case of phosphor bronze. Even to-day there is no ternary equilibrium diagram for this widely used alloy. The only work in this direction is found in an Italian journal for 1907. If only academic workers would realise that 80 per cent. of the world's production of non-ferrous castings consists of either gunmetal in some form, manganese brass or phosphor bronze and that the scientific data we possess on these alloys is small.

* A Paper to be presented before a joint meeting of the London Branches of the Institute of Metals, and the Institute of British Foundrymen, Mr. V. C. Faulkner presiding.

Problems of Furnaces and Melting Practice.

The one phase of bronze foundry practice where the progress for the last 20 years has been practically negligible is the melting practice. From time to time new furnaces and new methods of melting are heralded, but, despite these, the coke fired pit furnace is still the favourite method of melting for casting. This is especially remarkable when one considers the extremely low thermal efficiency of this furnace. In the best cases it is not above 6 per cent. and more generally about 3 or 4 per cent. Table I shows the approximate

TABLE I.—*Furnace Thermal Efficiencies.*

	Per cent.
Coke-fired crucible pit furnace-natural draught	3 to 7
Coke-fired crucible tilting furnace	8 to 13
Oil or gas-fired crucible tilting furnace ..	7 to 18
Reverberatory furnace	12 to 20
Cupola	30 to 40
Small electric furnace	40 to 65
Large electric furnace	60 to 85

thermal efficiency of the more common types of furnace. Both fuel oil fired and gas fired crucible furnaces have had a very fair trial in this country, but only in a few cases are they being operated to-day. They certainly possess some advantages over coke-fired furnaces, but it is difficult to operate them so cheaply, despite the many claims which have been made.

Coke-fired crucible tilting furnaces are much more common and these may be said to be a type which will stay for a long time. The efficiency is higher than a pit furnace, but more experience is needed by the furnaceman as the crucibles have a very short length of life, unless the furnaces are carefully operated.

The crucible costs are a very important factor in bronze melting. The average present-day costs of melting and casting a ton of metal in small quantities for small work is about 45s., of which about 14s. is for crucibles. Hence the many attempts of the foundryman to find a suitable non-crucible type of furnace. There can be no question that the crucible pit-fire natural draft furnace

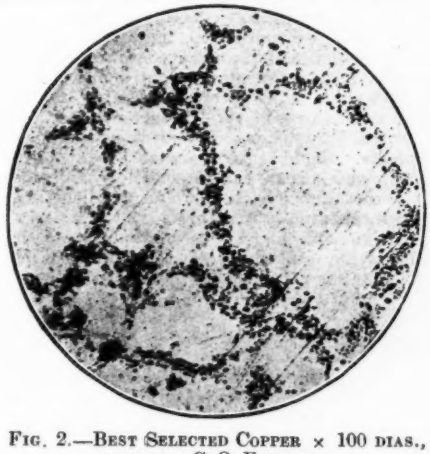


FIG. 2.—BEST SELECTED COPPER × 100 DIAS., SHOWING CuO EUTECTIC.

constitutes a method for melting which has not yet been excelled on the score of the quality of metal produced. The writer would not care to say that it cannot be equalled, but with other types of furnaces the danger of adversely affecting the quality of the metal is much more great and thus the skill of the operator needs to be corresponding greater.

Open type furnaces working with various fuels usually give considerably lower melting costs and are, of course, the only type used for melting large quantities of metal that is from 15 cwts. upwards.

Excellent results can be obtained from these, providing the furnace atmosphere is kept just right—again a matter needing considerable skill—but these have yet to displace crucible furnaces for the majority of work.

The British foundryman has frequently been upbraided for his lack of enterprise in not adopting electric furnaces more extensively for non-ferrous work, but critics should remember that the seemingly more enterprising American is able to obtain electric power at competitive rates, and that also the non-ferrous foundryman is more sceptical on account of the many shortcomings of the electric furnace in steel foundry work, particularly when compared with the acid converter.

The choice of, and care devoted to, furnaces for melting non-ferrous metals do not yet seem to obtain the consideration they warrant in most foundries. Whilst the general trend of modern practice is to devote great care to analytical and pyrometic control, the importance of correct melting practice is not sufficiently realised.

Problems of Correct Melting.

It is not generally known how simple it is irreparably to ruin a bronze by incorrect melting practice. The dangers of oxidation during melting are far more prevalent than is often imagined. On account of the difficulty of detecting oxide in a bronze, its presence, even in extremely deleterious quantities, is often overlooked. Some of the most susceptible alloys to maltreatment in this direction are the alloys of the gunmetal class that is bronzes with or without small percentages of phosphorus and zinc.

Unfortunately, analytical results do not give any clue to the presence of oxide, and even careful microscopical examination may not give any definite evidence if the alloy contains lead or non-metallic impurities other than oxide. Probably the best guide to the presence of oxide in a bronze is the appearance of the fracture of a sample cast under good conditions as regards casting temperature, etc. Should the fracture be intergranular or show red specks, the presence of oxide is practically certain. Fig. I shows an excellent example of an intergranular fracture. The sample is from a consignment of war scrap—phosphor bronze bushes from gun limbers. The analysis of the particular sample is shown in Table II.

TABLE II.—*Analysis of Oxidised Bush.*

	Per cent.
Copper	86.7
Tin	10.5
Lead	0.71
Zinc	1.21
Iron	nil
Phosphorus	0.36
Arsenic	0.004
Antimony	0.002
	99.576

It will be seen that the analysis presents no unusual features although too much zinc is present for a good class phosphor bronze. The fracture, as will be seen, is completely intergranular and the dendrite formation of the separate grains is shown up remarkably well. The only unusual feature in the microscopic appearance of such a bronze is the presence of hair-like films usually starting from a patch of eutectoid and running to another patch or bordering a patch of eutectoid.

Cause and Prevention of Oxide.

The presence of such oxide is due primarily to faulty melting and mixing practice. The basis of all bronze is, of course, copper. Although electrolytic copper cathodes are fairly extensively used nowadays, the major portion of castings are produced with ingot copper. For casting, that brand known as "Best Selected" is generally purchased. Best Selected ingot copper usually contains 99.6 to 99.75 per cent. copper, the balance consisting of various impurities including oxide. The oxygen content varies from 0.05 to 0.3 per cent., and is easily visible under the microscope, as shown in Fig. 2.

The metal then is initially oxidised. That some further oxidation occurs in melting is inevitable, but careful practice will keep this at a minimum. Melting without a cover, prolonged melting, exposing the unmelted or partially melted ingots to an oxidising flame will all soon raise the oxide content to a highly undesirable level. Furthermore, one very seldom starts with all new metal in bronze-foundry practice—scrap generally forms from 40 to 70 per cent. of the charge—all of it containing more or less oxide. The question naturally arises, why not deoxidise the metal after melting? This is a far more difficult thing to accomplish than is generally realised. According to technical literature, phosphorus is one of the most powerful deoxidisers known. This widespread faith in the efficacy of phosphorus is touching but, unfortunately, misplaced. Whilst it is perfectly true that phosphorus will reduce cuprous oxide, it is not generally realised that it is of little value to reduce tin oxide. The writer has had numerous instances of the presence of large quantities of tin oxide present in bronzes containing anything up to 1.5 per cent. phosphorus.

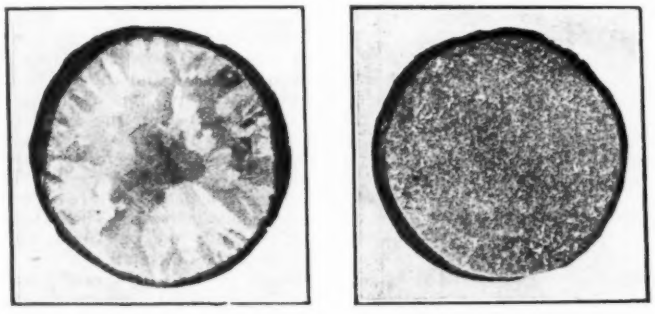


FIG. 3.—ETCHED MICRO-SECTIONS SHOWING THE INFLUENCE OF CASTING TEMPERATURE ON THE GRAIN SIZE.

In fact, none of the commercially-used so-called deoxidants seems capable of removing tin oxide from a bronze. Phosphorus may be called the friend of the poor foundryman. It enables him to transform a pot of bronze which is so full of oxide that it is like treacle, into a free-running metal which, nevertheless, still contains its oxide and will give hopeless castings from the standpoint of strength.

The best way to deoxidise a bronze is not to oxidise it. No amount of "dope" will replace correct melting practice and make rubbishy scrap into new metal. In this connection the importance of adding the tin to a bronze, last thing of all, should be noted. Every precaution must be taken to preclude the possibility of tin oxide. The phosphor-copper or phosphor-tin or zinc or manganese copper or whatever alloy is preferred must be added before the tin, and stirred in and allowed time to react.

Runners and Running and Pyrometric Control.

Probably the most important factor in the making of bronze castings is the method of running and feeding the castings. This is especially true in castings of any appreciable weight. There are one or two axioms which are easily stated and the truth of which will readily be admitted, but to carry these out in actual practice—with due regard to economical considerations—is frequently very difficult. One of these axioms is that the mould should be filled at every point with metal at the same temperature. The perfect achievement of this ideal is naturally difficult, but

the manner in which some foundries run their castings throws light on their difficulty of obtaining a high percentage of really good work.

Another is that the runner should be so placed that the metal is agitated as little as possible inside the mould, and so that the metal does not flow with any force against the sides of the mould. The best results in bronze-founding practice are always obtained by running the casting as rapidly as possible consistent with avoiding undue agitation and scabbing of the moulds.

Whatever results are obtained in cast-iron founding small runners are of no value in bronze-foundry practice where good results are imperative. The subject of casting temperature is intimately bound up with the question of methods of running, and one cannot logically be discussed without the other. That the casting temperature of an alloy is an important point everyone now agrees, but mere discussion of casting temperature without reference to the size of the casting, the thickness of section, and the size of the runners is valueless and meaningless.

It has been the author's privilege during the last few months to visit a number of non-ferrous foundries—some up-to-date and some out-of-date—and he was rather pleasantly surprised to note that nearly every foundry had pyrometers; and if these were not used as regularly as one might think necessary, they were invariably used on heavy or important work.

The regular use of a reliable pyrometer in all bronze foundries is a practice which is to be strongly commended, as by this means one phase

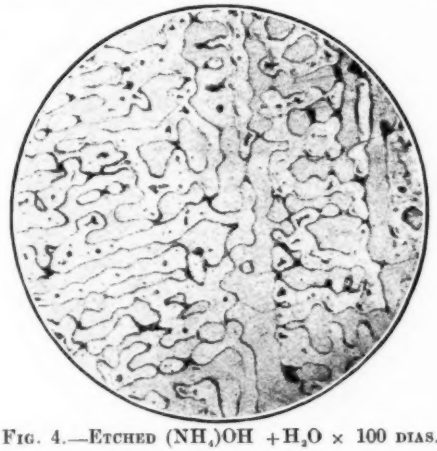


FIG. 4.—ETCHED $(NH_4)OH + H_2O$ × 100 DIAS.

of bronze-foundry practice can be standardised and valuable data obtained. One point with regard to the fixing of casting temperature-limits perhaps deserves to be mentioned. The generally prevalent idea is that the heavier the section of the casting the lower the casting temperature should be. This is not always strictly true, as a very important factor is being neglected if only this aspect is considered. That is the distance the metal has to travel to the farthest point of the mould. It should be realised that once the metal has entered the mould the temperature falls with great rapidity, so that by the time it has travelled a short distance the temperature is very different from that of the metal in the pot. Thus in fixing the casting temperature, this very important factor must be taken into consideration. The casting temperatures used for the bronze alloys lie between 1,000 deg. and 1,250 deg. C., the average being 1,100 and 1,200 deg. C.

Liquation, Segregation and other Problems.

One of the most serious troubles in bronze-founding practice in the past has been defects due to heterogeneity of castings. High-tin bronzes, particularly those containing phosphorus, are very liable to give trouble in this respect. Consisting, as they do, of two quite distinct phases, solidifying over a wide range of temperature, due consideration must be given to freezing conditions to obtain a homogenous casting of good physical properties. Naturally the lighter castings do not present any difficulties in this respect, as immediately the casting is poured solidification takes place throughout, and there is very little possibility for segregation or liquation to occur.

With the ordinary tin bronzes, the solidification commences at 990 deg. C., and is complete at 790 deg. C. With phosphor-bronzes the solidification commences about 960 deg. C., but the alloy is not finally set until the freezing point of the ternary eutectoid, namely, 620 deg. C. Thus the possibilities for liquation troubles to occur are greater with phosphor-bronzes than with plain bronzes or gunmetals. The effect of variations of casting temperature and rate of cooling on bronze constitute an almost unlimitable field for research, the fringe of which has only yet been touched. Only a few of the main effects can be stated with certainty. The lower the casting temperature of the bronze (other things being equal) the greater will be the Brinell hardness and the greater the density. Also the lower the casting temperature the smaller will be the grain size, as shown by etched microscopic sections such as those in Fig. 3. This is due to the rapid rate of cooling through the primary solidifying range, and corresponds with the small grain size shown by chilled castings. Low-casting temperature in bronzes gives rise also to greater segregation of the eutectoid, which is not often a desirable feature. When the eutectoid form an almost continuous network or is segregated in large patches instead of being formed in smaller sized, isolated and evenly dispersed nodules, the alloy is considerably more brittle and weaker to shock. Figs. 4 and 5 show samples of bronze of the same composition which illustrate the effect of low-casting temperature on the eutectoid segregation. Variations in casting temperature have also a marked effect on the colour of the fracture of a bronze. Bronzes with 10 to 12 per cent. tin when cast at a high temperature (1,175 to 1,250 deg. C.) break with a golden-brown fracture, whilst those cast at a low temperature (1,075 to 1,125 deg. C.) have a greyish-white fracture. The appearance of fractured runners, etc., together with the microscopic appearance, and in conjunction with the size of the runner thus enables one to make a very close estimate of the temperature at which the metal was cast.

Where the strength of a cast-alloy is the primary consideration, it should be remembered that the conditions which tend to give a bronze of the greatest strength are rapid solidification from a fairly low-casting temperature and very slow cooling after solidification. Such conditions obtain in test bars attached to large, heavy bronze castings. A test bar attached to the bottom of the casting and cast in such a manner as to solidify rapidly, will give very good results due to the slow cooling after solidification.

Tin-sweat.

This method is, of course, similar in some respects to casting a chill bar and subsequently annealing and slow cooling, which invariably gives higher test results than can be obtained by other methods. A comparison of the effects of various rates of cooling on strength is given in Table III, which illustrates the points enumerated

TABLE III.—*Effect of Varying Solidifying Rates and Cooling on Admiralty Gun-Metal, Analysing Copper,* 87.44; *Tin,* 10.43; *Lead,* 0.27, *and Zinc,* 1.66 *per cent.*

Casting temp. Deg.	Method of moulding.	Maximum Stress. Tons per sq. in.	Elongation. Per cent.
1120	Attached to 15 cwt. casting.	21.8	27
1140	Loose green sand.	17.2	18
1140	Chilled and subsequently annealed.	23.4	32

Size of Test Bar in each case 1¼" round.

above. One of the most familiar examples of liquation in bronzes is seen in high tin bronzes, particularly those containing phosphorus. This is generally and expressively known as "tin-sweat."

In its less harmful form it is seen to advantage on the runners of high-tin, high-phosphorus bronzes cast at high temperatures when the exuda-

tion from the runner may often be sufficient to cover the whole of the runner head. It is also fairly frequently seen on the top surfaces of castings after machining, grey hard spots generally having minute pellet holes all round the outside edge. These spots may be sufficiently extensive to cause rejection of a casting, and very often they extend deeper than is at first imagined. The author recently saw a case of "tin-sweat" on a large phosphor-bronze casting weighing about one ton, in which the actual "tin-sweat" was over 18 in. long by 2 in. to 3 in. broad, and was over $\frac{3}{8}$ in. in depth.

The "tin-sweat," in all cases, whether seen in the casting or on the runner, consist chiefly of what eventually becomes the delta eutectoid, and (if the alloy is phosphor-bronze) copper phosphide. The author has, at different times, had analyses made of such exudations from bronzes, and a sample of such analyses is given in Table IV. Table V gives the analysis of the exudation or tin-

TABLE IV.—*Typical Exudations from Bronze Castings.*

	Copper	Tin.	Lead.	Zinc.	Phosphorus.
Casting ..	89.0	9.35	1.24	1.20	nil
Exudation ..	77.12	17.36	4.48	0.76	nil
Casting ..	88.03	10.70	0.33	0.46	0.16
Exudation ..	80.26	18.24	0.77	0.16	0.41
Casting ..	87.88	10.23	0.87	0.41	0.44
Exudation ..	78.82	19.29	1.40	0.29	0.92
Casting ..	86.11	12.54	0.21	0.16	0.89
Exudation ..	77.18	20.37	0.33	0.12	1.75

TABLE V.—*Analysis of a Large Phosphor-Bronze Casting Weighing 19 cwts.*

	Casting Per cent.	Exudation Per cent.
Copper	87.5 ..	80.9
Tin	10.6 ..	18.2
Lead	0.15 ..	0.46
Zinc	0.30 ..	0.45
Phosphorus ..	0.40 ..	0.74

spot on the large phosphor-bronze casting mentioned above, together with the analysis of the main body of the casting. It is interesting to note that where the alloy contains lead a much larger proportion of lead is found in the exudation.

Cause and Remedy of Tin Spots.

The causes are too high casting temperature and insufficient feeding of the metal. The solidification of high-tin bronzes seems to proceed to two distinct phases—more distinct than one would imagine from the thermal equilibrium diagram. The alpha solid-solution of the alloys freezes, and the subsequent contraction of this network causes the still liquid portion of the alloy to be squeezed out.

If a heavy mould is poured at a high temperature and the runners and risers are so small that feeding is impossible, the liquid shrinkage will cause the metal to leave the top of the mould at the place where the metal is hottest (near the runner), and the subsequent cavity will be filled up by exudation of the low-melting point compound causing a tin spot. The remedy is to cast at a lower temperature—and if this is impossible because of the distance the metal has to travel—cast with as large a runner as possible in order to enable the casting to feed itself from the runner. The head of the casting should be both of large volume and good depth to give the requisite pressure head, and remain fluid the requisite time.

The reverse of this "tin-sweat" problem is also possible and interesting. If a piece of phosphor-bronze is heated up to 620 deg. C. the low melting-point compound will exude, and only this compound will exude until a very much higher temperature is reached.

The author has examined bronze bearings which have heated up and seized in service where the temperature attained has been high enough to cause this exudation, and the journal has been cemented to the bearing by this exudation.

In one instance the quantity exuded was sufficient to enable an analysis to be made, the results of which are shown in Table VI.

TABLE VI.—*Exudation from Seized Bronze Bearing.*

	Composition of bearing.	Composition of exudation.
Copper ..	84.09	72.48
Tin	13.87	21.59
Lead ..	.74	4.98
Zinc	.88	Trace
Phosphorus ..	.030	.030

Blowholes.

Blowholes are troubles which the foundryman will always have with him. In a well-regulated foundry, however, they should only form a small portion of the daily worries as the remedy is generally obvious and applicable. Probably the chief cause of blowholes in bronze-founding is cold metal. Very few commercial moulds are made which will not evolve a certain amount of gas when the hot metal is poured in. Provided, however, that a reasonable period of seconds elapses before the metal in the mould solidifies the reasonable amount of gas generated will not adversely affect the casting. But, if the metal is at such a temperature that it freezes as soon as it has filled the mould, the gas bubbles will remain as gas bubbles in the final casting, as the metal has not the chance to recover itself.

It must be admitted that certain metals and alloys have the exasperating habit of evolving gases at the moment of solidification. Pure copper is notorious in this respect, and many nickel alloys, unless carefully handled, fall from grace in this manner. It should, however, be a golden rule with foundrymen that whenever castings exhibit blowholes, the first thing that should be done is to try the effect of a casting temperature 50 or 100 deg. C. higher.

FIG. 5.—ETCHED $(NH_4)OH + H_2O$ × 100 DIAS.

Manganese Bronze.

Manganese bronze—or to give it its academic name, high-tensile brass—forms an extremely useful series of alloys adapted for foundry work, although their limitations in several directions should be realised.

Properly made, they have better physical properties than any other metal or alloy in the cast state; tensile strengths of over 40 tons per sq. in. being obtained with careful practice, whilst still retaining a remarkable ductility shown by elongations of 20 per cent. or over. Probably the major portion of the manganese bronze produced finds its application in marine engineering. It is the alloy almost universally employed for propellers owing to its strength and toughness and satisfactory resistance to corrosion and erosion. It should, however, be mentioned that aluminium bronze propellers have been and are being tried for this duty, and may quite possibly become serious competitors in this direction owing to their extreme resistance to corrosion by sea water.

The author has, at times, cut up castings made from manganese-bronze supplied to give anything from 35 to 45 tons tensile which have failed to pull 10 tons. The successful production of manganese-bronze castings is a matter requiring considerable experience often bitterly purchased, and is not to be lightly undertaken.

The hardening elements used by different firms vary considerably, but the examples given in Table VII represent typical practice. It is prac-

tically useless for a foundry which has not expert metallurgical knowledge and a chemical laboratory at its command, to attempt to produce really successful manganese-bronze castings as the effect of the hardening elements and alterations in composition are profound. The high shrinkage and other founding difficulties have prevented the more widespread use of this alloy for smaller castings.

TABLE VII.—*Typical Industrial Manganese Bronzes Analyses.*

	High grade.	Medium grade.
Copper	55.4 per cent.	58.5
Tin	Trace	1.3
Lead	nil	0.78
Zinc	37.6 per cent.	38.00
Iron	0.86	1.04
Phosphorus	Trace	Trace
Aluminium	2.50	Trace
Manganese	3.25	0.80
Physical Tests.		
Yield point	.. 21.4 tons per sq. in.	17.8 tons per sq. in.
Maximum stress	44.8 ,, ,, ,,	37.6 ,, ,, ,, ,,
Elongation	.. 24 per cent.	19 per cent.
Reduction	.. 23.6 per cent.	20 ,,

Aluminium Bronze.

Most bronze-founders have at some time or other had at least an attempt to produce successfully sand castings in aluminium bronze. The remarkable physical properties given by this bronze and the apparent simplicity of manufacture form a great attraction. It is quite safe to say, however, that not many founders in this country could be found to undertake the production of anything like complicated sand castings in this alloy at a commercial price. The whole difficulty of aluminium-bronze founding may be summed up in the word "oxide." When some genius finds a really successful flux or deoxidant for this alloy then it is likely to become a serious rival to the ordinary bronzes.

Curiously enough, aluminium-bronze is far more successful as an alloy for permanent-mould castings. There are quite a number of firms in this country producing small, intricate castings in this alloy in cast-iron moulds. The achievements of our American friends in this direction are well known. Where castings of any appreciable weight or section—that is, when the thickness is over 1 in. or the weights over 50 lbs.—are to be produced by this method, the difficulties are rather great on account of high-liquid shrinkage of the alloy. It is reported, however, that in America castings of plain section up to 100 lbs. in weight are being successfully produced.

Alloys to Resist Corrosion.

One of the greatest problems connected with modern brass-foundry work is the production of a commercial alloy to resist corrosion. Judging from current technical literature and trade advertisements, one is apt to think that the corrosion problem is nicely settled now that stainless steel is available, but, unhappily, it is not so.

Whilst stainless steel represents a metallurgical achievement, little short of marvellous, combining as it does an alloy of remarkable physical properties with great superiority in resistance to corrosion to ordinary steels, yet for serious corrosion-resisting duties in very few cases is it superior to or even equal to such commercial non-ferrous alloys as the nickel-copper group typified by the alloys known as Monel metal and Corronil.

For feebly-corrosive mediums of a non-acidulous character, especially when erosion and abrasion occur, stainless steel is the best metal yet produced. There is, however, a very large field for an alloy which can be handled fairly easily in the foundry and which has good anti-corrosive properties.

Such an alloy should have also fair strength and good machining properties. Many of the cast nickel-chromium-copper alloys give very excellent anti-corrosive properties, but the difficulties attendant on casting these alloys into anything but the simplest shapes are very great.

Generally speaking, the aluminium bronzes are more resistant to corrosion than the ordinary bronzes, but here again the difficulties of founding prevent their widespread use. The cast alloys of copper, nickel and aluminium, with between 5 and 10 per cent. of the latter metals, are comparatively simple to cast, and besides showing remarkable resistance to corrosion in some media, give excellent physical properties. Such alloys as the copper-silicon and copper-silicon-manganese, also present distinct possibilities.

Possible Future Developments.

It is extremely presumptious for anyone to attempt to prophecy what bronze-founding practice of the future will be like. One of the comparative certainties is the great extensions that are likely to be made in the use of aluminium-alloy castings—particularly die castings and permanent-mould castings for small work. The cheapness, lightness and comparative ease with which such castings can be made by those methods will result in time in the majority of small non-ferrous castings being made in such alloys. In this connection, particular mention should be made of the aluminium-silicon alloys, which have probably a brighter future before them than any other aluminium alloy yet developed. The development of non-ferrous alloys having really good anti-corrosive properties and suitable for casting purposes is long overdue. No alloy to resist corrosion is likely to have a wide use unless it can be handled in the foundry with comparative ease. Alloys containing percentages of nickel between 5 and 15 per cent. to replace tin-bronzes are likely to become common unless, of course, the Dutch financiers decide to sell tin to the foundries at £100 a ton.

If all our mooted water-power schemes come to satisfactory fruition or any of the bi-weekly newspaper stories of cheap electricity ever result in power at a farthing a unit, we shall then see wholesale adoption of electric furnaces.

Vote of Thanks.

THE CHAIRMAN (Mr. V. C. Faulkner) said that this was the fourth of a series of lectures which had been delivered under the joint auspices of the two bodies. The first lecture was by Mr. S. E. Wells, the second by Dr. Longmuir, the third by Mr. A. H. Munday, and the fourth was by Mr. Rowe, who was a member of both societies. They attached a good deal of importance to these lectures, because the Institute of Metals, taken as a whole, treated rather of the academic side of metallurgy, whereas the Institute of British Foundrymen dealt with the technical and practical side, but they met on definite technology, of which Mr. Rowe was a very good representative, being a man who was familiar with the latest academic thought, and also with practice in the shops.

DR. J. L. HAUGHTON (Chairman of the London Section of the Institute of Metals), proposing a vote of thanks to Mr. Rowe for his lecture, said he was sure they had all listened to it with the very greatest pleasure. It was a real treat to have a lecture such as this, by a man who combined both scientific and practical knowledge in a way which had been made so very obvious to them. Speaking for the members of the London Section of the Institute of Metals, he said it was always a great pleasure to them to have these joint meetings with the Institute of British Foundrymen, and they had always been very fortunate in having excellent lectures on those occasions. Mr. Rowe's lecture stood out as a very successful and a remarkably interesting one, and he had great pleasure in proposing a vote of thanks to Mr. Rowe.

MR. WESLEY LAMBERT (Past President of the London Branch of the Institute of British Foundrymen), who seconded, said he had enjoyed the lecture very much indeed. There was one proposal he would like to make to Mr. Rowe, namely, that in his reference to manganese bronze, he should delete the word "grade." It would be better to talk of high "tensile" and medium "tensile" than of high and medium "grade." At his works on the following morning they would be casting a very large propeller, weighing 28 tons, and he could assure them that he would not attempt to get anything like a figure of 46 tons tensile, because he would consider it most dangerous to put such a metal into a large propeller.

The vote of thanks was accorded with acclamation.

"Tales from the Gangway."—Owing to a printer's error, the price of this book was given as 10s. post paid, instead of 15s.

Moulding Machine Developments.

Our representative recently had an opportunity of inspecting the works of the Denbigh Engineering Company, Limited, of Tipton, Staffs, who are the patentees and manufacturers of the "Its It" jolt moulding machine. During the visit a demonstration was carried out on their new model machines which they have named the "Denbigh Marvel." From the moulds made, both on straight lift and turnover types, the claim of the makers that these new models totally surpass the original "Its It" in all respects is justified.

FIG. 1.—A STRAIGHT-DRAW HAND-JOLTING MOULDING MACHINE WITH A RIDDLE ATTACHMENT.

With a wooden frame on top of box to hold sufficient sand for packing down, moulds were made with eight jolts, that were sufficiently hard for steel castings without any flat ramming. This efficiency of the jolt is obtained from the new construction.

The greater ease in operating is attained by the use of a multiple of light springs for balancing the load on table instead of the one strong spring which was used in the original models. Also there is now no changing of springs, as each machine is fitted with springs that will deal from the lightest to the maximum load on table. The same simple oil device for adjusting the load is used as on the "Its It," and this method operates on all springs equally.

FIG. 2.—HAND-JOLTING ROLL-OVER MOULDING MACHINE.

Among the many features of these machines is that the first three sizes can be made portable if desired, and this enables a system of moulding that undoubtedly proves a distinct time-economiser. This system has been adopted by the Denbigh concern in their own foundry and resolves itself into stacking boxes in lots of 12 pairs at intervals of space they will occupy when made up ready for casting. This gives, say, for 72 boxes six stacks at the required spacing. The operator moves the machine to the first stack of boxes where there is also a dump of sand at the side, and as the moulds are made he places them immediately behind him and then moves the machine to the next stack and repeats the operation. By this method there is practically no carrying of boxes and the operator does not have to move many feet throughout the day.

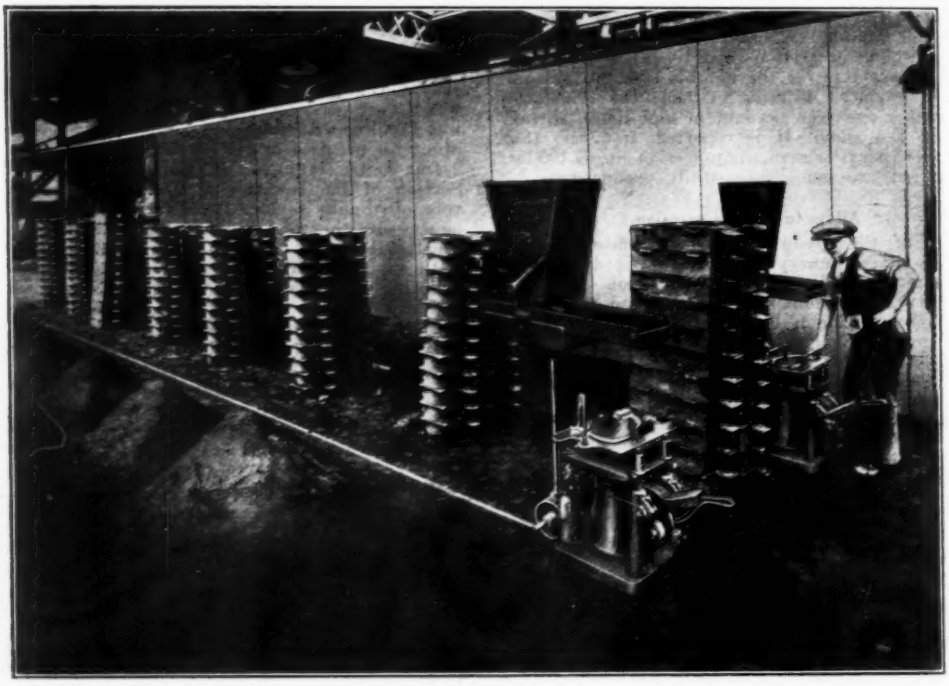


FIG. 3.—VIEW IN THE FOUNDRY AT THE COMMENCEMENT OF THE DAY.

The same system applies when boxes are opened up and again stacked, with sand dump at side of boxes instead of carting sand and boxes to the machine as is necessary with stationary power machines.

The straight draw machines are at present being made in six sizes up to 1 ton, and the turnover machines in four sizes up to 10 cwts. Any shape of box can be used, as the necessary adjustment to lift them is very simple. The machines, being entirely hand-operated, dispense with any auxiliaries whatever, and the upkeep is therefore at a minimum, with an output that is claimed to be equal to any power machine.

Another interesting and new departure noted in this foundry was a patented hopper and riddle for distributing facing sand over pattern. This is fixed to a bracket on the machine out of the way of the operator. By lifting a lever sufficient sand is allowed to fall from the hopper to the riddle. The riddle which is contained on guides running on rollers is then pulled out, and a few jolts is all that is necessary to cover the pattern, thus effecting an appreciable saving of time and riddles.

The illustrations Figs. 1 and 2 show respectively a straight-draw machine with the riddle attachment, and a turnover machine. Figs. 3 and 4 illustrate the system of bringing the machine to the work as carried out in the Denbigh Engineering Company's foundry.

FIG. 4.—THE BOXES ARE NOW READY FOR CASTING, AFTER WHICH THE SHOP WILL AGAIN ASSUME THE APPEARANCE SHOWN IN FIG. 3.

BEFORE THE BIRMINGHAM UNIVERSITY METALLURGICAL SOCIETY, Mr. A. J. G. Smout has delivered an address on "Fuel Economy, with special reference to the Metal Industry."

AN INQUEST has been held at West Hartlepool concerning the death of J. F. Watt, chargeman moulder, as the result of an accident at the Central Marine Engine Works. J. McAndrew, who was working with deceased and a squad of men preparing a mould, said he was in the mould when suddenly he was covered with dust, and Watt fell in head first. J. H. Kirk said he slung a wooden pattern of a cylinder chest on to a travelling crane. He did not know how much the pattern weighed. He shouted "all clear" two or three times, and when the crane commenced to move he walked in front of it to keep people clear. He heard a shout, and on looking back saw that the pattern had fallen, two of the battens having given way. The jury returned a verdict of "Accidental Death," and recommended that slingers be employed at each crane.

Institute of British Foundrymen.

LANCASHIRE BRANCH (Junior Section).

The Junior Section of the Lancashire Branch of the Institute of British Foundrymen held a meeting, for the purpose of electing its officers, at the College of Technology, Manchester, on Saturday, December 13. The officers so elected will manage the business of the Branch until the General Business Meeting in April next.

The newly-elected officers were:—

President.—Mr. R. W. Stubbs, Manchester.

Vice-President.—Mr. Norman Masters, Stalybridge.

Council.—Messrs. Heywood, Walsh, Eastwood, Harrison, McKenzie and Yeoman.

Hon. Secretary and Treasurer.—Mr. G. R. Bean, Manchester.

Messrs. R. A. Miles and T. Makemson respectively, President and Secretary of the Lancashire Branch, are *ex-officio* members of the Council.

After the election of officers, a Paper on "The Value of Technical Information in Foundry Work" was read by Mr. F. W. Rowe, B.Sc., of Huddersfield.

Mr. Rowe dealt with the influence of the various constituents of cast iron upon the properties of the iron, and showed the necessity for exercising control over the composition. He also dealt with the methods of testing employed in works practice, and showed the value of microscopic examination.

The new Junior Section is in a very flourishing condition. The attendance at this meeting was as large as that of the opening meeting on November 15. The membership is now 230, and applications are being received almost daily.

Mr. T. Makemson, Secretary of the Lancashire Branch, or the new Secretary of the Junior Section, Mr. G. R. Bean, 44, Taylors Road, Stretford, Manchester, will be glad to give information to intending members or to employers who may be interested.

BEYER, PEACOCK & COMPANY, LIMITED, have an order from the Bengal-Nagpur Railway Company for two "Garratt" type articulated locomotives, which will rank as the most powerful railway locomotives built for India. These locomotives will be of the 2-8-0 0-8-2 wheel arrangement, the coupled wheels being 4 ft. 8 in. and the bogie wheels 3 ft. diameter. The boilers will be the largest ever designed for locomotive purposes in this country.

XUM

Testing Castings.*

By F. C. Edwards.

Nothing so much enhances the reputation of a firm, or brings more grist to the foundry mill generally, than the establishment of efficient methods of testing castings. Indeed, it is no exaggeration to say that the foundry industry can only hold its present ground and obtain its share in the ever-extending field of engineering by ensuring the reliability of its product.

In status, as well as financially, the trade has in the past suffered incalculable harm through the lack of this desideratum. Even to-day engineers frequently exhibit a more or less unjustifiable reluctance to employ castings because of an innate and apparently ineradicable belief that they cannot be depended upon.

This condition of things may be remedied. Haphazard and empirical methods, though excusable—perhaps essential—in the incipient stages of the industry, need not be tolerated to-day. Although

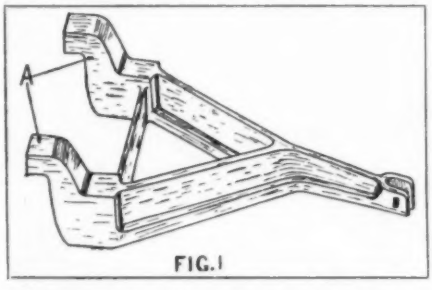


FIG. 1

foundry work is not yet an exact science, sufficient is known to enable castings to be delivered as free from flaws, and as exempt from potential failure, as components manufactured in another way. For this, however, a knowledge of the capabilities and limitation of castings under given conditions for designer, producer and user alike, is necessarily imperative.

By tests to destruction of various forms the designer is enabled to gauge their relative strengths. He discovers for himself that certain types of design give appreciably higher ratios of efficiency, weight for weight, than other types. He may even find that, in some circumstances, the addition of metal has actually had the effect of weakening instead of strengthening a casting, and, conversely, that the judicious removal of metal may confer extra strength. He will thus be in a

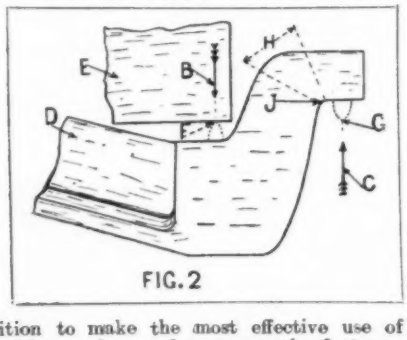


FIG. 2

position to make the most effective use of the metal he employs and to ensure the first requisite for the production of sound and reliable castings—correct design.

The founder, by means of systematic testing, may keep his mixtures and methods tuned up to concert pitch, so as to secure a continuous output of castings, correct—within negligible limits—to specification.

With definite and guaranteed data at his command the user of castings is encouraged to rely and to draw more and more upon the vast potentialities of the modern foundry.

Now it is not proposed, in the confines of one short Paper, to attempt any such pretentious task as that of dealing—even in a general manner—with the whole gamut of systems at present in vogue for testing castings. The mere enumeration of these presents a most formidable array. There are the various kinds of physical tests, ranging from the rough and ready blow of a hand hammer to the more scientific tensile, transverse, impact, compression and hydraulic tests (as in the testing of cylinders, etc.), which again may be divided into actual and representative; tests for hardness, which include the drill test, the Brinell and the scleroscope. Then there are the analytical tests, by means of which the relative proportions of the constituents of a given alloy may be more or less accurately estimated to several places of decimals. Further, microscopic and macroscopic tests enable one to investigate the structure of a metal or alloy, and, by inference, to judge of its properties, while photomicrography permanently records such tests, and, by allowing comparisons to be made of the size, distribution, and configuration of the several constituents, furnishes to the observant metallurgist what is unquestionably the test of an alloy *par excellence*. Finally, where expense is no object, X-ray tests may be carried out on castings, and blow-holes and porosity exposed in their otherwise inaccessible lairs.

Testing castings is more than a mere final check. It should include an inspection of the history—and even the birth—of a casting. That is, one should start with design. The utility of testing castings with a view to improvements in design is not, perhaps, so generally realised as it deserves to be. For this reason, it is proposed to devote this Paper mainly to an example of this kind of

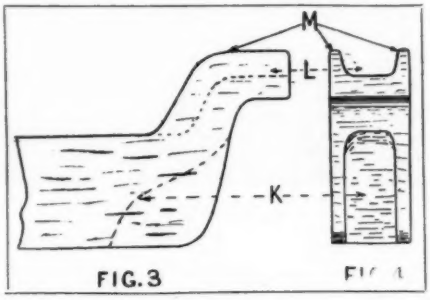


FIG. 3 FIG. 4

testing from the experimental stage to the final product. The grounds for the various steps will be given in detail, in the hope that they may prove of general interest and may point the way to successful action in other cases.

Test bars in one form or another have long held a very important place in the testing of castings. Specifications for castings usually call for a certain size of test bar, the nature of the test, and whether the bar is to be cast separately or attached to the casting. In their proper domain test bars are invaluable. There seems to be a tendency, however, especially in circles outside the foundry, to regard a test bar as being synonymous with a test of the actual casting itself. This, for demonstrable reasons, it can never be. Further, exclusive reliance upon the data of test bars cannot be too strongly deprecated.

With regard to the form, number, and dimensions of standard test bars for universal application, it seems to be a case of "who shall decide when doctors disagree?" For amongst experts, both national and international, there are on these points notorious differences of opinion. Some argue that one size alone of test bar would give all that is required to be known—indeed, all that can be known—from this form of test. Others hold that three (or more) bars of different sectional areas give truer representative tests of the castings to which their respective sections most nearly approximate than one bar could possibly give.

The triple-bar standard would appear to be more generally satisfying—if not actually more serviceable—than that of the single bar. For,

* A Paper read at Newport, Mon., before the Wales and Monmouth Branch of the Institute of British Foundrymen, Mr. B. Hird presiding.

although a test bar is, strictly speaking, a test of the metal and not of the casting, it does undoubtedly serve as a more or less representative test of the latter. Castings which differ in section may be expected to differ in their rates of cooling. Now it is, of course, well known that the rate of cooling materially affects the strength of a casting. A test bar may therefore be regarded as a truer criterion of its casting when the cooling-rate factor is common to both. This is especially applicable when the test bar is attached to the casting.

But there is another and perhaps stronger argument for the three-bar standard, namely, that different mixtures may not give correspondingly parallel results for respectively identical differences of section. Two mixtures, for instance, may exhibit, say, a 20 per cent. difference in tensile strength when tested in circular bars of 1 sq. in. sectional area; the same mixtures, when tested

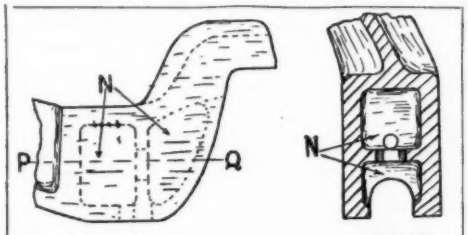


FIG.5

FIG.6

in circular bars of only ¼ sq. in. sectional area, may be found to be practically identical in tensile strength.

With the object of obtaining actual data on this point the writer recently carried out a series of tests on round and rectangular bars respectively. Tensile test bars, 12 in. long, were cast in two forms—circular and rectangular. The rectangular bars were 2 in. × ½ in., 2 in. × ¼ in., and 2 in. × ½ in. These, of course, gave sectional areas of ¼ sq. in., ½ sq. in., and 1 sq. in. respectively. The circular bars were cast as near as possible to sizes which correspond to the above sectional areas—namely, 0.564 in. dia., 0.798 in. dia., and 1.132 in. dia. The bars were cast from two different mixtures. One, suitable for light, general work, containing 3.3 per cent. silicon, the other, a 10 per cent. semi-steel, with a 2 per cent. silicon. Three bars of each size and composition were cast, and the average results of the test were as detailed in Table I:—

TABLE I.—*Tests on Round and Rectangular Test Bars.*

Size of Bar.	Type.	Breaking load.	Max. stress.
		Tons.	Tons per sq. in.
0.564 in. dia.	General	4.0	16.0
0.564 ,, ,, ..	Semi-steel ..	4.18	16.72
0.798 ,, ,, ..	General	7.1	14.2
0.798 ,, ,, ..	Semi-steel ..	8.3	16.6
1.132 ,, ,, ..	General	12.05	12.05
1.132 ,, ,, ..	Semi-steel ..	15.0	15.0
¼ in. × 2 in. ..	General	5.0	20.0
¼ in. × 2 in. ..	Semi-steel ..	5.31	21.24
½ in. × 2 in. ..	General	7.54	15.08
½ in. × 2 in. ..	Semi-steel ..	9.65	19.3
2 in. × 2 in. ..	General	13.0	13.0
2 in. × 2 in. ..	Semi-steel ..	16.0	16.0

From a comparison of the above tests it will be seen that the rectangular bars give higher values, unit for unit, than those of circular cross section. Further, the difference becomes increasingly pronounced as the sectional area is reduced. A comparison of the mixtures, however, shows the difference in value, section for section, operating in the opposite direction. At the smallest sections, indeed, both round and rectangular, the difference in tensile strength between the 3.3 per cent. silicon "general" mixture and the 2 per cent. silicon semi-steel is practically inappreciable. The above differences are attributable, of course, to the effect of the varying rates of cooling on the different sections and mixtures.

With the smaller sections there would be a higher rate of cooling, which would tend to produce a finer grain structure, thus giving a greater tensile strength. The rectangular bars, of course, owe their superiority over those of circular cross section to the more uniform rate of cooling throughout their cross sectional plane. The noticeable approach to vanishing point, *pari passu*, with the diminution of sectional area, of the manifest advantage possessed by the semi-steel in the larger sections, is due to the increasing influence of the temperature factor; the greater tendency to graphite growth in the high-silicon mixture over that of the lower silicon semi-steel being increasingly neutralised as, with the reduction of sectional area, the rate of cooling is accentuated.

It would appear, therefore, to be extremely difficult—if not impossible—to fix upon any one standard size of bar which would be universally comparative for all sections and mixtures. And it follows, of course, that from a choice of, say, three bars one could obtain more dependable tests (because more closely representative) than when one is limited to a single bar.

There are other experts, again, who consider that the form of the bar section—*e.g.*, round or square—has an important bearing on the efficacy of the test. The advocates of the round bar point to the greater regularity of cooling effect as compared with that of the bar with square corners; whilst the supporters of the square bar rely upon the fact that, with most castings, the square or rectangular section predominates.

To obtain a more closely representative test than either that of the separate test bar or of the bar attached to the casting, some contend that a casting should be tested, say, as one tests a cheese—by gouging out with a hollow drill—a test bar from the casting itself. This is known, of course,

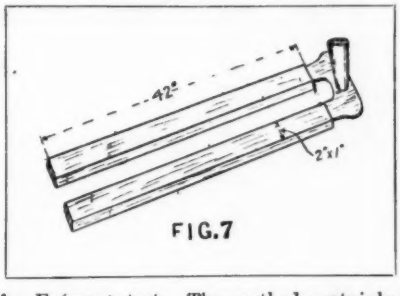


FIG.7

as the Frémont test. The method certainly possesses the virtue of eliminating all possibility of inadvertent or unscrupulous substitution of test bars. It does not, however, convert a representative test into an actual one. For even this form of test bar is essentially but a gauge of the quality of the metal in the casting.

Regarding the test bar as a measure of the *metal* strength, its ideal form and the conditions under which it is made and tested should be of such a nature as to ensure its complete immunity from the effect of extraneous fluctuations—*i.e.*, variations in production or testing other than those arising from the constituents of the metal or alloy.

But, after all, the user of castings is normally more concerned with the strength or suitability of the actual castings themselves than with their estimated strength as obtained from test bars, however closely representative these may appear to be. Since most castings are far more complicated than test bars, the ultimate test of a casting lies beyond the province of any merely representative test, whether physical, chemical, or micrographic.

There are at least three reasons for this. The first lies in the obvious difficulty of determining by theory the exact nature and direction of the various stresses to which a casting is likely to be subjected when in service; the second is the problem of proportioning the various parts of the casting so that those stresses may safely be carried with a minimum expenditure of metal; the third (and, in some cases, the most tantalising factor to cope with, even by the method of trial and error) is the ever-present question of cooling or contraction strains.

Although the writer does not, of course, advocate the general smashing up of castings in order to test their strength, it must be admitted that a complete solution of the above problems lies in the physical testing of the actual castings. (This

is rigorously carried out on certain castings to-day.) Or, where size precludes this, reduced facsimile models of the portions more particularly under stress in service will answer almost equally as well. In repetition work, especially, such experimental testing is of the utmost value. It promotes reliability, and enables the most economical proportions of a casting to be ascertained.

Experimental Testing.

In the following example experimental testing enabled a radical alteration to be made in the design of a component, giving a stronger casting, and at the same time effecting a 15 per cent. saving of metal. And there could be no greater tribute, perhaps, to the efficiency of the methods employed than the fact that, although these castings have been sent to many parts of the world, and are in service subjected to varying degree of shock, there is so far no record of a single casting having been fractured either in transport or service.

The component referred to is that of a triangular lever, as used in a weighbridge, and shown in Fig. 1. The tests were mainly concerned with the "feet" A, an enlarged view of one of which is shown in Fig. 2. In this kind of testing, of course, one must first consider the probable direction of the stresses to be carried. In this case it should be noted the stresses on the "feet" in service are in the direction of the arrows B and C, Fig. 2.

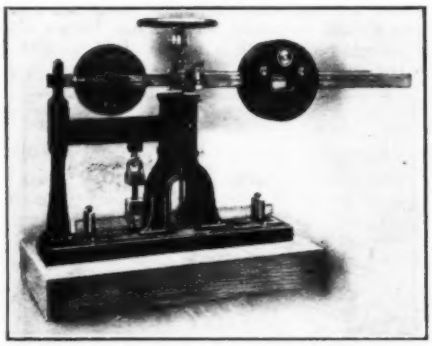


FIG. 8.—AN AVERY NO. 624 BAR TESTER.

By inverting the figure, therefore, and assuming end D to be anchored down on wall E close up to bearing F, the problem resolves itself into that of a cantilever. It will easily be seen that with the load on knife-edge bearing G the casting would be likely to fracture somewhere between the limits indicated by H, starting from tension flange J. Preceding rupture, the outer surface about H, would thus be in compression. In practice fracture does actually occur on these lines.

Originally these feet were made solid. The dimensions were arrived at in the ordinary way by computing the various stresses, and, by the application of a safety factor, assuming a certain minimum strength for the metal. Incidentally, this practice (and it is, of course, almost universal) ignored vital metallurgical considerations. Later, it was considered that a much lighter foot might give equally good results as that of the heavy "mass" section, especially as the latter was occasionally found on fracture to have harboured gaseous inclusions.

Two half-size models of the foot were made, one solid and the other recessed, similar to that shown at K and L, Figs. 3 and 4, which represent side and end views respectively of the foot. Castings were obtained from each under the same moulding conditions, and poured from the same ladle. These castings were then tested to breaking point, the load being applied in a similar manner to that to which the actual castings were subjected in service. The solid foot broke under a load of 9.4 tons, the lightened foot broke at 11.3 tons.

A little consideration will show that the above result is not, perhaps, so astonishing as it may at first sight appear. The rupture undoubtedly starts at the tension flange J. The outer ribs M are thus merely compression members. And this outer surface, though materially relieved, is still far less likely to yield under a compressive stress than the surface J is under tensile stress

Metallurgical conditions apart, then, and with strict regard to working stresses, the removal of this metal does not militate against the strength of the foot. Regarded from a metallurgical point of view, however, a decided accession of strength is the expected sequence of the lighter section. It is, of course, common knowledge that in a casting the strength per unit area decreases with increase of section; conversely, as the sectional area is decreased a higher unit strength is obtained. The variation is a function of the rate of cooling. Furthermore, in a heavy section, on account of liquid contraction, there is always a strong probability of porosity being present at the centre of the mass. In the present case the removal of the redundant metal from the compression side of the foot, by speeding up general cooling, actually confers a corresponding increase of strength upon the tension flange.

The most suitable proportions having been obtained by experiment with the models, the feet of the particular full-size lever, of which they were reduced facsimiles, were correspondingly modified. In addition to this, the body part of the foot was cored out at N, Figs. 5 and 6, (Fig. 6 being a sectional plan at P, Q, Fig. 5). Finally, one of the feet of an actual lever casting was tested beyond the required safety factor limit. This limit, which is considered ample for all contingencies with this particular size of lever, is 20 tons. The load was increased, however, to 27 tons. It was then removed, as it was not considered necessary to carry it any farther.

Securing Uniformity of Production.

The same moulding methods as those by which the actual test casting was made are regularly practised. Then a close identity of material is maintained by daily tests. A pair of transverse test bars are made from the same metal as that put into the castings. These bars are 42 in. × 2 in. × 1 in. Originally three pairs were made, one at each end, and one at the middle of the cast. It was found, however, that there was no appreciable variation, so the test bars poured at the middle of the cast were alone retained. The date of cast and the initial letter of the mixture is cast on one end of each bar. The bars are tested, usually the day after being cast, and permanent records are made. The bars are subsequently used for purposes of analysis. The method of moulding the bars is shown in Fig. 7.

The machine on which the tests are carried out is known as the "Avery No. 624 Bar Tester." Tensile tests can be made on the same machine. In the transverse tests the test bar is supported, but not fixed, 3 in. from each end. This, of course, on the 42-in. bar gives a span of 3 ft. between the centres. The load is applied upwards in the centre of the bar by a hand-wheel at the top. It is communicated through the medium of an intermediate lever to the steelyard. Here it is balanced off by a poise propelled by a hand-wheel at the head stock.

The weekly record of transverse tests is made out as shown in Table II, which represents actual tests recently made:—

TABLE II.—*Weekly Record of "Weighbridge" Metal.*

Breaking load (in cwts.).	Deflection (in inches).	Fracture.
35.10	0.330	Sound and close.
33.75	0.356	" " "
35.50	0.383	" " "
34.60	0.321	" " "
34.60	0.332	" " "

In addition to the above daily transverse tests, weekly tensile tests are taken. For these the test bars are of circular cross section. They are cast as near as possible to 0.798 in. in dia., which gives an area of ½ sq. in. Incidentally, this size simplifies the process of testing—the stress per sq. in. is obtained by doubling the load registered by the machine. Permanent records of these tests are kept for periodic examination, or for customers' or their Inspectors' satisfaction.

Testing the Pig-iron.

This Paper would be incomplete without reference being made to the testing of the pig-iron.

Before a consignment of pig is unloaded it is tested as follows:—Two pigs are taken—one from each end of the truck—immediately on arrival. They are broken through the middle and a short piece broken off. Six holes are drilled in the fractured face of the piece. The drillings are analysed the same day. If found satisfactory, the pig is unloaded and stacked according to composition and fracture.

Now, although the chances are very remote of a serious drop in the quality of the metal, it is still a possibility. Herein lies the unanswerable argument for frequent testing. When any deterioration is observed, immediate steps are taken to ascertain the cause. This may be attributable, say, to a variation in the composition or fracture of the pig-iron, or to a falling off in the quality of the scrap. Or possibly the coke contains more than its normal proportions of sulphur. Or, again, there may have been some negligence in weighing the charges. Or the weighing apparatus may need attention—a quite conceivable possibility indeed, when one remembers the rough treatment to which it is naturally exposed in the foundry yard. In any case, the trouble can be ascertained and remedied.

In certain classes of work where, on account, say, of the stringency of Government Regulations, tests are carried out on actual castings, railway chairs, for instance, furnish a typical case in point. In some foundries one or two castings from every cast are tested to destruction. Naturally, a more powerful testing machine is required than that for an ordinary test bar. A very suitable one for this and similar tests is that known as the Avery 30-ton compound lever machine, which operates as follows:—The specimen is placed in position and the "presser foot" lowered on to the casting. The machine is put in gear. The poise is run out to keep the steelyard in equilibrium until the required stress is obtained, or until the casting is fractured.

It is not suggested, of course, that all castings should undergo such a rigorous test as that described above for railway chairs. It should be obvious, however, that if the products of the foundry are to secure that confidence which—thanks to exhaustive testing—is to-day placed in those of most of the allied trades, the methods of testing must be thorough.

Three main factors govern the strength and serviceability of all castings—namely, form, material, and methods of production. It would be difficult to differentiate between the relative importance of these three factors. Castings cannot exist, of course, without form. Further, the strength of a casting, with material and weight constant, varies with its shape. Without material, again, the most minute casting could never emerge from the realms of imagination. And it needs no argument to prove that good castings cannot be produced from bad material. Equally necessary are methods of production. These, again, may be reliable or otherwise.

Now, since the above three factors each play an indispensable part in the production of castings, and since castings approach 100 per cent. efficiency in proportion to the level of production attained by each factor, it follows that, for complete testing, every factor must be taken into account, and the efficacy of the test is to that extent vitiated. The test is more or less a sham; it may be, indeed, a delusion.

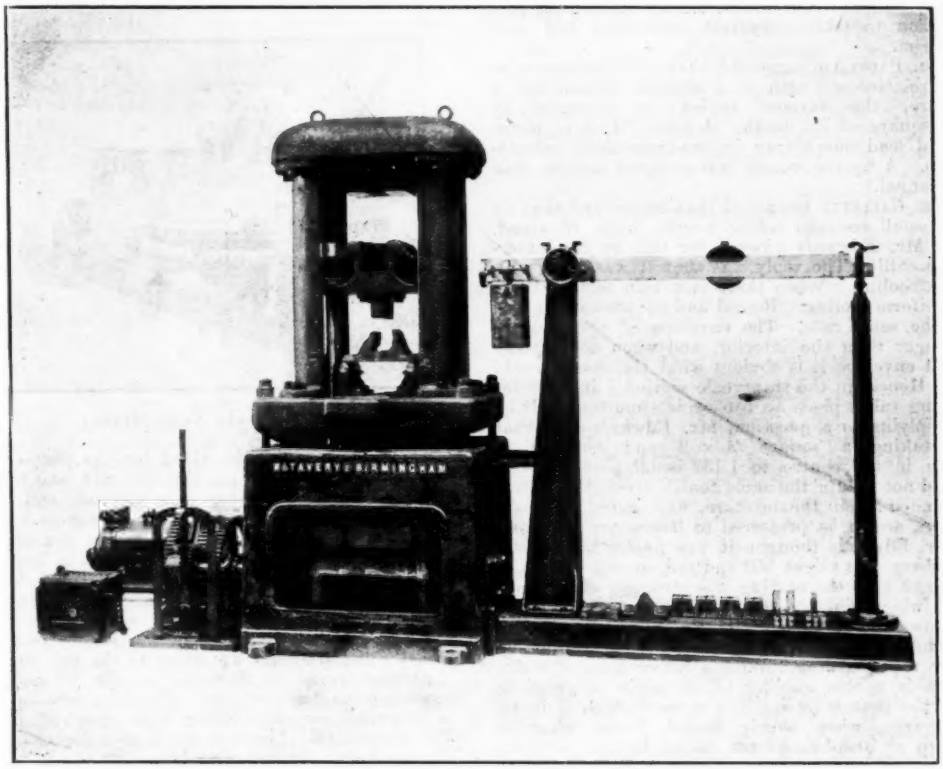


FIG. 9.—A 30-TON TESTING MACHINE FOR RAILWAY CHAIRS.

Thorough testing, on the other hand, enables the founder to guarantee his product. It leads to economy of metal and reduces scrap. Above all, it is calculated to allay, in the mind of the user of castings, long-held doubts, and to substitute a wholesome trust, beneficial to all parties concerned, in the creations of the Cinderella of engineering.

In conclusion, the author wishes to express his sincere thanks to his employers, Messrs. W. & T. Avery, Limited, Birmingham, for kindly permitting him to make the tests referred to in this Paper.

DISCUSSION.

MR. J. MCCLELLAND said that the lecturer gave an illustration of some round castings which he was in the habit of making which had quite a thick rim, but were much thinner in the centre. On picking one of these up it broke, and, to avoid this in future, ribs were added, running across the casting. Mr. McClelland asked would not the trouble have been obviated had the periphery been cooled at a greater rate than the centre? He contended that the strain would still exist, in spite of the ribs, and that a more reliable casting would be obtained by cooling the periphery. He also

asked could the lecturer give some idea of the pressure the T-section would stand compared with the same area of metal in a square bar.

MR. EDWARDS thought it was a very important point raised by Mr. McClelland, and said that the diameter of the rim was 18 in., and had they been able to cool both simultaneously they would have eliminated future breaking. By putting on ribs the strain will exist as long as the casting lasts. One must agree that unless one can eliminate cooling stresses they do exist in castings, more or less, as long as the casting is a casting. In this particular case the effect of these ribs is dual. The first is the cooling of the casting is rendered more even because there is a continual line across the casting and increased metal in various directions. Secondly, this rib being a rib acts as a cooling factor itself and helps to bring about strength, because the rib cools on the straight line and helps to keep the plate straight. The objection to resorting to artificial cooling methods is that every casting would have to be attended to, and in mass production it is the wrong practice. His firm perhaps make from four to five hundred of these per week, and it would not be a very economical proposition to take every one separately and cool the rim.

MR. PADFIELD suggested that with reference to the relative strength of a channel section and a square, the former varies in strength by the square of its depth. A heavy block of metal would lead one astray in mathematical calculations. A square section is considered weaker than a channel.

MR. GALLETLY remarked that he noticed that on the small sections better results were obtained. Did Mr. Edwards account for this by the superficial chill? The reply was that it was more uniform cooling. When there is a thin section there is uniform cooling. Round and square cannot cool at the same rate. The envelope of a casting is stronger than the interior, and when the casting is all envelope it is obvious what the result would be. Hence, in the transverse section ¼ in. × 2 in. cooling takes place on each side simultaneously.

Replying to a question, Mr. Edwards said that by taking a square 2 × 2 and turning it down in the centre to 1.132 equal to 1 in., one would not obtain the same tensile strength. Much depended upon the mixture, and sound practical figures are to be preferred to laboratory research.

Mr. Edwards thought it was preferable to cast test bars on a slight hill and not on end. He also thought that the casting was stronger when cored than when solid, the reason being that as the stress is low the tendency is for it to break up. Secondly, cast iron is stronger, up to a point, by more rapid cooling. With a heavy mass of metal there is a slow cooling which tends to graphite growth; that is to say, the carbon which is in all cast iron, when slowly cooled, forms what is known as graphite plates, which have a weakening effect upon the casting. Slow cooling increases the growth of these graphite plates. Hastened cooling results in the graphite remaining in a finer state. There is no stress in the centre. In the neutral axis no strength is required, because there is no stress and metal is taken away when there is no stress, which hastens the cooling and gives extra strength.

Replying to a question by Mr. E. H. Davies, MR. EDWARDS said that if a test bar were cast on the casting, probably lower results would be obtained than when cast separately. He thought it would be preferable to run the test bar from the gate if care be taken not to get dirt into it. The lower the test bar is cast, the better the metal therein.

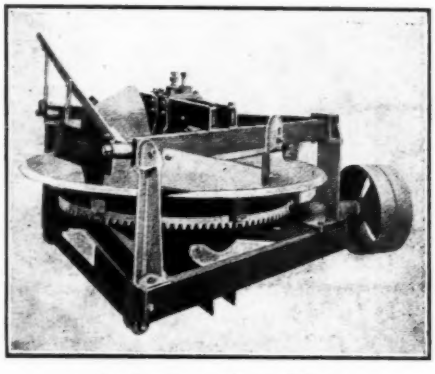
The meeting closed with a vote of thanks to the lecturer.

Foundry Statistics.

During October the United States exported 3,373 tons of pig-iron, 3,501 tons of cast-iron pipes, 687 tons of iron castings, and 492 tons of steel castings, whilst they imported 10,963 tons of pig-iron. Germany exported 3,053 tons of pig-iron, 3,814 tons of cast-iron pipes, 480 tons of cast-iron rolls, and 6,766 tons of other castings during this month, whilst they imported 24,684 tons of pig-iron, 2,341 tons of cast-iron pipes, 1 ton of cast-iron rolls, and 357 tons of other castings.

Improved Foundry Sand Mill and Mixer.

A new type of foundry sand mill and mixer has been designed and placed upon the market by E. T. Neal & Company, Limited, Water Street, Kettering. It is covered by Patent No. 191,208/23. The essential feature of this mill, which is illustrated below, is the sloping side to the pan and the conical shape of the roll. The sloping side of the pan gives much greater rubbing surface to the roll and at the same time makes it possible to discharge the material when mixed over the side of the revolving pan. The roll is held down on to the pan surface by means of springs acting on the roll shaft, which allows of any desired tension to be applied. The makers claim this mill to be much more rapid than the ordinary sand mill, and the sand with its constituents is thoroughly toughened in the pan. This mill is also more readily transformed into a mixing mill for mixing core-sand and oil—which it produces in a thoroughly kneaded state. All that is necessary



AN IMPROVED SAND MIXER.

is to lower a scraper provided for the purpose in front of the roll, when the material will pass round the roll instead of under to be ground, and only comes in contact with the mixing scrapers.

The method of discharge is by means of a special scraper which is lowered on to the pan in front of the roll and which causes the material to ride up the side of the pan and discharge over the side at one spot. The mill is fitted with ball-bearing toe-step and ball bearings in the cross stretcher, whilst roller bearings are fitted to the roll shaft.

Another point of interest is the method of renewing the false bottom. The false bottom lies in a recess somewhat wider than the roll path. The renewal is therefore much cheaper than in the ordinary sand mill with false bottom the whole width of the pan.

Catalogues Received.

Doors and Runways.—Messrs. Richards-Wilcox Canadian Company, Limited, of 93, Stamford Street, London, E.C.1, have sent us their English Catalogue No. 1. Its appeal is very mixed, as it deals with "door hangers, hardware specialities and garage door hardware." Primarily it is designed for architects or builders, but much of the manufactures described are suitable for works, and we suggest the scope is sufficiently large in this country to cover a special one containing a direct appeal. We also suggest the title should be "British Catalogue." For foundry owners this catalogue presents interest so far as runways and workshop doors are concerned.

MR. FRANK RUSSELL, F.G.S., F.E.S., of the General Refractories Company, Limited, Sheffield, has been elected President of the Geological Section of the Sorby Scientific Society for the ensuing year, and Mr. Charles H. Ashton, a member of the same firm, has been elected secretary of the section.

Heating and Drying in Foundries.

By Arthur Ryner.*

The drying of moulds and cores, the heating of ladles and shanks, of ingot heads and moulds, etc., have recently been receiving considerably more attention in view of the increasing cost of fuel and the need of the utmost efficiency necessary for meeting foreign competition.

Many foundries in this country are still using methods which are far behind those used by our foreign competitors. Often no records at all are kept of the quantities of fuel used for each separate purpose in a foundry, and no instruments are used to determine the most suitable temperature for each operation. But most of the waste is due to antiquated inefficient methods for producing the heat and for applying it.

Abroad, and especially in the most modern German foundries, most of the mould drying is done on or in the floor, even comparatively small moulds are dried *in situ*. Cores and very small moulds are dried in pits specially built for the purpose, and the scarcity and low quality of the fuel obtainable had led to the introduction of combustion apparatus capable of extracting all the heating value of the fuel and applying it in the most direct way.

The problem of drying consists of two parts; the first is the apparatus for producing the heat, the second its application. One of the most efficient apparatus for producing heat, and which has been adopted by hundreds of foundries all over Europe, is Oehm's heating element. It is a simple box divided into two compartments, one of which serves as a kind of gas producer. The second compartment, separated from the first by a firebridge, contains specially shaped ducts and a jet through which a small quantity of compressed air impinges upon these ducts. The compressed air used, preferably at a pressure of about 80 lbs. per sq. in., induces a draught through the first compartment containing the fuel. The carbon monoxide is carried over the firebridge, is then intimately mixed with the incoming compressed air, and carried over the louvred ducts which, being heated to a high incandescence, cause the carbon monoxide to be completely burned to carbon dioxide. This gas then issues at a temperature of over 1,400 deg. C. with considerable pressure and at a velocity of several hundred feet per second. The combustion is so complete that neither flame nor smoke is produced. Because of the velocity of these gases they can be carried considerable distances without losing their heat.

It will be seen that this apparatus is entirely different from the so-called portable driers in which a fan is used to aid combustion. In these fan-blown driers the pressure obtainable can only be a few pounds above atmospheric pressure. The combustion is therefore less efficient, and it is necessary to allow plenty of exits and orifices in the mould for the products of combustion to escape, otherwise back pressure will stop combustion altogether.

Advantages of Floor Drying.

Contrary to the opinion often expressed in this country, floor drying is far more economical in every respect in labour, time and in floor space than drying in drying stoves, provided that efficient heaters are used and not open coke baskets.

In the first place, floor drying permits of the individual drying of each mould, and each mould is only heated as much as is absolutely necessary, whereas in stove drying in the ordinary way all moulds are left for the same length of time in the drying stove whether they require it or not. In many cases the moulds are dried far longer than is necessary.

Where suitable apparatus is used, permitting the moulds to be temporarily closed and the heat to be forced into the cavity, that heat is applied to drying the sand where it is needed to be dried, and none of it is wasted in heating up thick cast-iron boxes or the air in the drying room.

Drying by means of hot gases under pressure is far more rapid because the pressure can be utilised to distribute them and lead them to wherever they are required, and because for proper drying not only high temperatures but also rapid circulation is necessary to carry away the moisture. Whereas in this country one often hears of moulds being dried for two or even three days, on the Continent very large castings rarely take more than eight hours for complete drying.

A large proportion of the moulds in the foundry do not need very much drying, and do not carry a very large body of sand. In their case from half-an-hour to two or three hours is sufficient to dry them properly for casting purposes, and it therefore follows that most of these moulds can be cast on the same day on which the mould is finished.

Present Position of Floor Drying.

There is, of course, a fair amount of floor drying done in this country, but the methods employed are extremely wasteful compared with Continental methods, both in fuel, labour and time. The most common method used in this country, that of open fire buckets placed into the mould, has a series of disadvantages; in the first place, it involves a considerable amount of labour—baskets have to be filled and lighted, and then to be carried into the

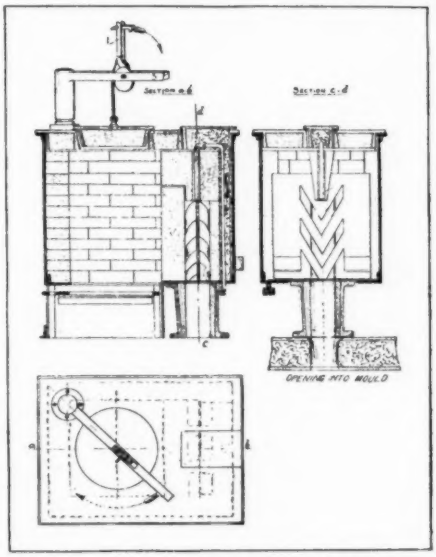


FIG. 1.—SECTION THROUGH OEHM'S HEATING ELEMENT.

mould. They are then usually left in the mould the whole night, the drying is uneven, and when they are removed the mould has to be cleaned, for all the ashes have dropped into it. Further, separate buckets have to be used for drying the cope, and, of course, the amount of fuel consumed by this bucket system, as compared with drying by gas under pressure, is infinitely greater. The time required is also from five to six times as much. This method has another great disadvantage, in so far as it first of all dries the surface of the sand, and then gradually draws out through the dried surface the moisture that lies underneath, which causes cracking of the surface, scaling and distortion of the mould. If gas under pressure is used the heat drives the moisture into the sand and then completely through it.

Apart from the cost of fuel when comparing floor drying with stove drying, there is the cost of power and labour required for picking up the moulds and taking them into the stove and out again. Investigation will show that the costs of this operation are very considerable.

Floor drying has to be done with proper regard to its possibilities; to get full advantage from floor drying with hot gases under pressure, it is

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necessary to study each mould on its merits. The most important matter is to drive the heat to the lowest possible point in the mould, for it rises naturally by itself. Where the blast of hot gases strikes the mould, the mould has to be protected from local over-heating by simply placing there a sheet of iron. Where more than one deep place exists in the mould, vents are made and connected with the deepest place in the mould by some kind of tube which causes the hot gases to travel downwards and then out through the tube. Time is saved and more equal heating is obtained where moulds are very long or of a very difficult shape by utilising two or more heaters at the same time. Where it is impossible to use several heaters at the same time it is advantageous to move the heating element every few hours so that the heat is applied at various points over the whole mould. That is the system which is generally adopted with very long and very broad moulds. As a general rule all vents are closed completely within a short time of starting drying operations, with the exception of perhaps one at the farthest end of the mould.

The Oehm Heating Element.

The composition of the gases from the Oehm heating element and its high pressure produces totally different drying effects from those which are produced by the drying methods which have been used hitherto or by portable drying-stoves actuated by fans. Owing to the low pressure in all these cases it was necessary to allow for free escape of the steam through chimney, or, where floor drying was resorted to, through the vents and risers. The hot-air dried the surface and produced a kind of caking which greatly hindered the further drying effects of the hot gas. The steam which was produced below the dried surface pressed upwards through it and caused cracking and scabbing and other troubles, so that in many cases floor drying was abandoned on account of these difficulties.

With Oehm's heating element all the orifices in

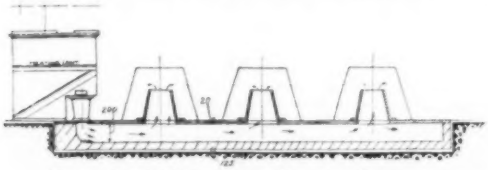


FIG. 2.—A METHOD OF DRYING LADLES.

the mould are carefully closed and the high pressure that is obtained drives the steam farther down into the body of the sand and then through it. The blacking is pressed firmly down and the mould remains porous and in a very advantageous condition for casting purposes. Very little care will ensure that the moulds are not burned, for as long as steam is formed inside the mould, no matter how high the temperature, the mould cannot be burned. As soon as the air that comes from the mould feels dry, which is easily ascertained, the mould is also dry and further heating is unnecessary.

A great advantage of the Oehm heating element is that once they are alight, practically anything that will burn can be burned in them.

There are a number of moulds, and, of course, all cores in a foundry have to be dried in a drying chamber or in a drying stove. The latest and the most modern Continental drying stoves take the form of pits in the ground. Pits have very many advantages; in the first place, a great deal of floor space is saved, for with the surface drying stoves sufficient room in front of the stoves must be kept free for the trucks upon which the moulds are loaded before they are pushed into the stove. Where pits are used no trucks are required, and a crane can pick up the moulds and drop them in the pit with the same amount of time and labour as would be entailed in taking them to the truck. Pits can be used for moulding complicated or difficult cores right in the pit, and another advantage is that, of course, a pit can be very much better heat-insulated than an ordinary drying stove. The cover of the pits can be made to fit very much better and sealed down, whereas doors are rarely a good fit.

As chimneys are not required where heating elements which produce hot gases under pressure and with velocity are used, the arrangement of pits is extremely simple. As compared with such modern arrangements many of the drying stoves used in this country are extremely inefficient; rarely has any attention been paid to proper insulation, and the amount of heat radiated through the walls is quite considerable. Very rarely is the heat properly and equally distributed over the whole of the drying stove. Of course, with the firing arrangements in use in this country, proper distribution is scarcely possible, and as a result the temperature varies very considerably in different parts of the drying stove. Furthermore, where plain, open fires are used for the drying stove, they are dirty, smoky and full of soot.

Oehm's heating elements are used in many foundries on the Continent for stove heating. The velocity with which the hot gases come out of the stoves is quite considerable, and that makes it possible to carry the hot gases without much loss of heat to any part desired. This is done by means of perforated pipes or trenches in the floor, covered by cast-iron plates spaced apart, so that the gases are equally distributed.

Where these heating elements can be used it will be found that the consumption of fuel used for bringing up the temperature of a drying stove, the author is convinced, can be cut down by 75 per cent. as compared with open fires. With the old type of drying stoves about 50 per cent. or more of the heat went out through the chimney.

Some of the heating elements mentioned above have already been introduced into this country, and have proved extremely successful in operation. They have been utilised for drying moulds on the floor; they have also been applied to drying stoves and drying rooms. They have been used for the heating of ladles, for which they have proved extremely successful, and for the heating of ingot moulds.

Fig. 2 shows the application of such heating elements to the heating of shanks. The system has recently been adopted for annealing purposes in which it not only proves very efficient and economical, but also very reliable, and, quite recently, for boiler heating. As compared with heating by ordinary town gas or by high hydrogen-content gas, these heating elements show a very great advantage, because they produce pure, dry gases, whereas from the ordinary town gas a very considerable amount of condensation takes place.

In conclusion, a few figures are submitted to show the amount of air and fuel consumed by Oehm's heating elements which are usually supplied in three sizes. The smallest size will use about 16 lbs. of coke or breeze per hour, about 300 cub. ft. of free air through the compressor and 3,250 cub. ft. of air through the fire-box. The combustion of the fuel produces 165,000 B.T.U. per hour.

A medium size heating element will use about 30 lbs. of fuel per hour, and 650 cub. ft. of free air per hour through the compressor: it will produce 330,000 B.T.U. per hour.

The largest size heating element will take about 56 lbs. of fuel per hour, consuming about 870 cub. ft. of free air through the compressor, and will produce 560,000 B.T.U. per hour.

The temperature of the hot gases issuing from these heating elements ranges from 1,400 to 1,600 deg. C.; the velocity of the gases, as they come out from the heating element, is over 100 ft. per second. The consumption of compressed air in the largest size unit is equal to about 5 units of electrical current per hour.

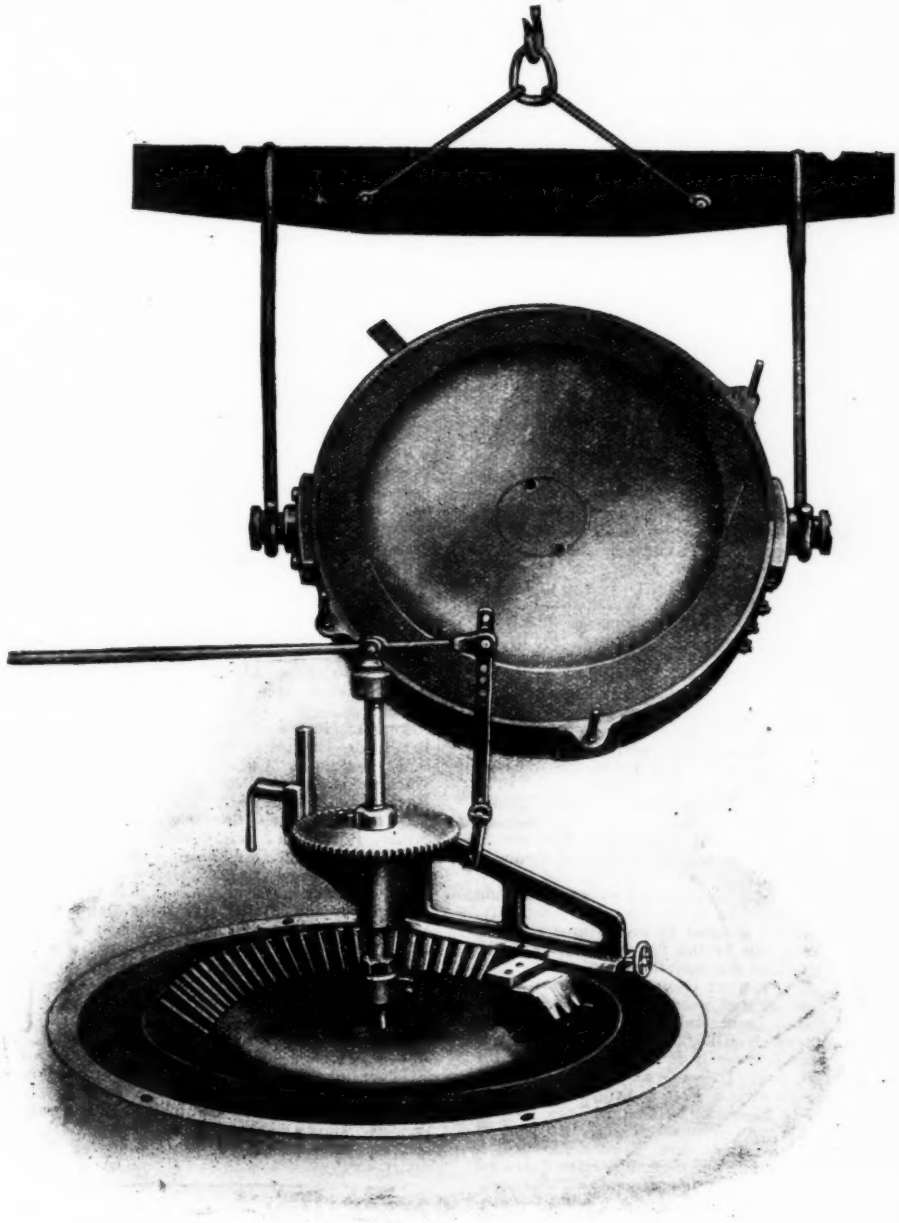
Economics of Iron and Steel.

The publishers of this book are Stevens & Sons, Limited, and H. J. Skelton & Company, Limited, of Royal London House, Finsbury Square, and not as printed in the review of the book which appeared on page 547 of December 25 issue.

MR. J. KENT SMITH, of Sheffield, who has often contributed articles to THE FOUNDRY TRADE JOURNAL on matters allied to the influence of vanadium on metals, is leaving England in the near future to take up his residence in the United States.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,

(MANCHESTER), LIMITED,

BLACKFRIARS, MANCHESTER.

Trade Talk.

THE NORTH BRITISH MOULDING COMPANY, LIMITED, 38, West Savile Terrace, Edinburgh, has been formed with a capital of £7,500.

THE TYNE SHIPBUILDING OUTPUT during the past year has totalled 65 vessels, with a tonnage of 274,557, an increase of 20 vessels and 120,499 tons over last year.

THE COHEN STEEL COMPANY, LIMITED, iron and steel merchants, have removed from Moorfields Chambers, 167, Moorgate, E.C.2, to Eldon Street, House, Eldon Street, E.C.2.

T. M. BIRKETT & SONS, LIMITED, brassfounders and engineers, Hanley, Staffs, have acquired the property, including the plant and machinery, at 38, Ilford Hill, Ilford, of National Alloys, Limited.

BRAITHWAITE & COMPANY, of West Bromwich, have received instructions from the Birmingham City Housing Sub-Committee to erect a group of six steel houses for the Birmingham City Council.

GJERS, MILLS & COMPANY, LIMITED, may shortly restart their Ayresome Ironworks. The firm contemplate putting two furnaces into blast on hematite about mid-January. The works have been virtually inactive since September last.

E. H. JONES (MACHINE TOOLS), LIMITED, Britannia Wharf, Baldwin Terrace, Wharf Road, City Road, London, N.1, have acquired the business of E. H. Jones, machine tool merchant, 18-20, Church Street, Islington, which has been transferred to Britannia Wharf.

AFTER BEING AT A STANDSTILL for some years the Egryn Manganese Ore Mines, near Barmouth, were re-opened on December 16. The promoters have constructed a line for over three miles along the mountain so as to bring the ore from the mines to the main road ready for railway transport.

THE CHILE EXPLORATION COMPANY, New York, have accepted the tender of Thos. W. Ward, Limited, of Sheffield and Silvertown, for the supply of 20,000 ft. of 8 in. dia. steel screwed and socketed piping for shipment to Antofagasta. We understand that this order was secured against keen competition from the United States.

THE DARLINGTON FORGE, LIMITED, have decided to add to their activities a large bronze foundry department, which will be equipped with all the latest appliances for turning out "Darlington" manganese bronze ships' propellers of the largest size. The manager of the new department is Mr. Henry Watson, late of Walkergate-on-Tyne.

THE ROTHERHAM HOUSING COMMITTEE has recommended that Mr. J. A. Potter, of the Tenter Foundry Company, Rotherham, be allowed to put up two houses, to be constructed mainly of cast-iron plates, according to the system of which he is the inventor. Recently, Mr. Potter submitted an offer to erect three pairs at £840 per pair, and this is the figure which is to be taken as applicable for the sample pair.

WEST'S GAS IMPROVEMENT COMPANY, LIMITED, Miles Platting, have just secured a contract for a carbonising plant from the Gas Light and Coke Company. The value of the contract is £120,000. Messrs. West have also secured contracts recently for Buenos Aires, of the value of £80,000, and Toronto, valued at £120,000, and, in conjunction with a French firm, a large contract for a complete gasworks at Prague.

THE SENTINEL WAGON WORKS (1920), LIMITED, of Shrewsbury, in association with Cammell, Laird & Company, Limited, of Nottingham, have secured orders for three two-compartment "Sentinel-Cammell" steam rail coaches for the Ceylon Government Railways, two coaches for the London and North-Eastern Railway, one coach for the London, Midland and Scottish Railway, one for the Entre Rios Railways, and one rail coach for the Hernosand Solleftea Railway.

IN REGARD TO THE CLAIM of Krupp's against Vickers, Limited, for royalties on shell-fuses used during the war, mentioned in our last issue, the claim is, according to a statement just issued in Berlin, made in accordance with the provisions of the Peace Treaty and the law of the Reich on the methods of procedure for the regulation of enemy debts, and that Krupp's were compelled to make it in order to avoid criminal proceedings and heavy penalties. The firm of Krupp, the statement says, has no interest in the issue. According to the law of the Reich relating to enemy debts about 99½ per cent. recovered accrues to the German Government. If Krupp's are successful, the German Government will apply the proceeds to the general clearing-house procedure with regard to enemy debts, in other words, paying off British claims against German debtor.

THE SUBJECT OF WIRE ROPES was discussed at a meeting of the Institution of Mechanical Engineers recently, when the second report of the Wire Rope Research Committee, Dr. W. A. Scoble, was read.

Company News.

A. M. Dickie & Sons, Limited.—Capital £5,000 in £1 shares. Engineers.

Howard & Bullough, Limited.—Quarterly dividend, 6d. per share, less tax, on ordinary shares.

Caxton Machinery Company, Limited, 74, York Street, Glasgow.—Capital £10,000 in £1 shares.

Wellman Smith Owen Engineering Corporation, Limited.—Interim dividend, 5 per cent., less tax, for year.

Jno. Hy. Andrew & Company, Limited.—No dividend recommended; preference dividend in arrear from June, 1922.

Boulton and Paul, Limited.—Net profit, £2,947; brought forward, £20,105; dividend on preference shares only; carried forward, £20,552.

North British Moulding Company, Limited, 33, West Savile Terrace, Edinburgh.—Capital £7,500 in 5,000 preference shares and 2,500 ordinary shares of £1 each.

Redfern Stevens, Limited, 177, Alma Street, Birmingham.—Metal goods manufacturers. Capital £10,000 in £1 shares. Directors: C. H. Stevens and A. H. Redfern.

J. Clarke & Company (Castings), Limited, 84 and 86, Lombard Street, Birmingham.—Capital £4,000. Metal manufacturers. Directors: T. A. Clarke (permanent) and W. T. C. Atkins.

Graham, Gillam & Company, Limited, 4, Iddesleigh House, Caxton Street, S.W.1.—Capital £10,000 in 9.500 ordinary shares of £1 and 10,000 deferred shares of 1s. Iron and steel dealers.

J. H. Lavender & Company, Limited.—Capital £4,000 in £1 shares. Metal founders. Directors: J. H. Lavender, "Charlemont," West Bromwich; Mrs. A. M. Lavender, "Charlemont," West Bromwich.

Paxton & Clark, Limited, Waverley Terrace, Bonnyrigg, Midlothian.—Capital £1,000 in £1 shares. Agricultural implement makers. Directors: A. C. Clark, C. Borthwick, B. J. Miller and J. Ainslie.

Joseph Thompson (Sheffield), Limited, Townhead Street Engineering Works, 41-3, Townhead Street, Sheffield.—Capital £10,000. Engineers and manufacturers of saws, etc. Permanent directors: W. and E. Thompson.

Charles Harlow & Sons, Limited, 16, Mill Street, Bradford.—Capital £100,000 in £1 shares (20,000 7 per cent. cumulative preference and 80,000 ordinary). Machine makers. Directors: H. A. Harlow, E. G. Harlow and G. Moore.

Grierson Ledway Company, Limited, 149, Ainslie Street, Barrow-in-Furness.—Capital £3,000 in 3,000 shares of £1 each. Engineers' furnishers and electrical engineers. Secretary: W. Grierson, 63, Westmorland Street, Barrow-in-Furness.

Nantyglo and Blaina Ironworks Company, Limited.—Net amount received from royalties and wayleaves, £27,586; from rent of land, etc., £8,411; total, £35,997; two instalments of dividend on account of arrears of dividends upon 8 per cent. preference shares, £25,000 paid, making together £5 per share; depreciation, £3,000; income from investments, £2,844.

John Hutchinson & Company, Limited, Western Mail Chambers, St. Mary Street, Cardiff.—Capital £20,000, to acquire the business of an iron merchant, engineering and general agent, carried on by J. Hutchinson as John Hutchinson & Company, at Western Mail Chambers, Cardiff, and elsewhere. J. Hutchinson will be permanent governing director and chairman.

AT THE MEETING of Baldwins, Limited, at Birmingham, on December 19, it was announced that the veteran chairman of the company, Sir John Roper Wright, had decided to retire from that position, which he has occupied with such distinction for so many years, though he is to remain on the board and give the company the benefit of his knowledge and long experience. Sir John will be 82 years of age next March. A letter was also read from Sir Robert Horne, M.P., resigning his position as vice-chairman of the company, already announced in these columns. Col. Sir William Charles Wright is to be chairman and Sir John Davies becomes vice-chairman. Sir John Wright has been a director of the company since its formation in the year 1902, and has acted as its chairman since the death of Mr. Alfred Baldwin in the year 1908. His colleagues on the board have felt that some recognition should be made of Sir John's services, and that this recognition is to take the form of creating the office of life governor and inviting him to accept the post at the same remuneration as he has received for his services in the past. Mr. H. G. Lewis has joined the board. Mr. Lewis is associated with Henry G. Lewis & Company, and is chairman of the Central Wagon Company, Limited, the Glamorgan Wagon Company, Limited, and the North Glamorgan Wagon Company, Limited.

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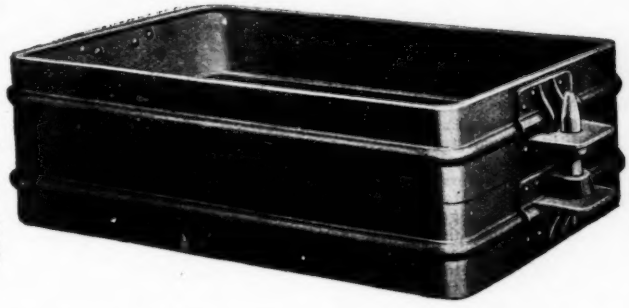

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—After what may be best defined as a blank week, the Cleveland iron market resumed active operations on a somewhat limited scale, the actual business transacted being entirely concerned with the more immediate necessities of consumers. It was only to be expected in the circumstances that quotations would be a trifle easier, and the outstanding fact really is that there has been so little change. At the moment export business is even quieter than the home trade, but there are hopes of a steady improvement in this respect. As regards prices, No. 3 G.M.B. is not more just now than 81s. per ton, but, on the other hand, there is no possibility of getting any further concession. No. 1 is 86s., No. 4 foundry 80s., and No. 4 forge 79s. 6d. per ton. In the Tees-side hematite trade the year ends on a decidedly more hopeful note than seemed likely a few months ago. East Coast mixed numbers are now quoted at 88s. per ton, with the No. 1 quality 6d. per ton more. On the West Coast prices are unaltered, Bessemer mixed numbers being quoted 97s. 6d. per ton delivered at Glasgow, 102s. 6d. per ton delivered at Sheffield, and 107s 6d. per ton delivered at Birmingham.

LANCASHIRE.—Resuming business after the Christmas vacation, the local markets for foundry pig have developed a more confident tone, while smelters are anticipating much better business in the year just commencing. Sellers of Derbyshire iron are still quoting 90s. per ton delivered in Manchester for No. 3 foundry pig, and there is a little Northamptonshire iron offering at rather less; but otherwise there is not a great choice of foundry iron at Manchester.

THE MIDLANDS.—Very little change in the conditions are expected in this district until after the quarterly meeting next week, when more definite information will be ascertainable as to the general position in the local industries. In the meantime, Northants No. 3 pig is very firm in price at 76s. to 77s. f.o.t., while Derbyshire No. 3 for immediate despatch is now offered freely at 82s. f.o.t., North Staffordshire iron remaining at 87s. 6d. f.o.t.

SCOTLAND.—Business in the Scottish industrial districts having been entirely suspended during the week, there is nothing fresh to record concerning the pig-iron trade, but prices may be taken as without alteration.

Finished Iron.

In South Staffordshire mills for the most part are inactive, and little new business is being done. Nothing has occurred to alter the quotations for crown or bolt irons, which remain at £12 15s. to £11 15s. per ton respectively. Belgian offers are being broadcast at figures varying from £7 10s. to £8 per ton delivered here for January/February delivery. Marked bars, which have not altered in price for nine months, are still the best market at £15 f.o.t. makers' works. The works making this quality of iron are well engaged, and have quite a good order book to commence the New Year. Iron plates are in good demand by the wagon builders, and the present quotation is £15 basis.

Steel.

In the steel market the sales of acid billets are on the small side, but basic dealings are, if anything, a trifle better. Steel manufacturers report a slight improvement in the call for high-grade material, but the chief business continues to be in the cheaper qualities. Business in alloys is quiet, but there is some improvement in demand for ferro-manganese, for which the price has been advanced 20s. per ton, the current quotation now ruling at £15 10s. delivered. There is no change to report in the market for tinplates, with quotations unaltered at the minimum official basis.

Scrap.

In the various markets for cast scrap dealers are now decidedly firmer than they were a short time ago. Some holders of the best kinds of foundry scrap, i.e., broken textile machinery iron, in Lancashire are asking 90s. per ton for it, delivered to buyers' works. Of course, such scrap is well worth the money, for after all it is only the price of common pig-iron, and at one time in the history of the Lancashire foundry trade this class of scrap used to fetch nearly as much as Scotch No. 3 pig-iron. Now Scotch is costing 107s. 6d. delivered here, and the scrap can be bought for 90s. Common cast scrap is also rather firmer than it was a week or two ago. Many dealers now quote 85s. where they were quoting 80s., and there seems to be a general expectation of a much better demand next year.

Metals.

Copper.—The position in the standard copper market at the opening of the New Year gives promise of increasing strength in values, due in part to more favourable New York advices, and to a general improvement in consumption both at home and on the Continent. Market opinion is consequently centred on the potential demand for copper, which may develop if trade continues on the up-grade, and views a steady improvement in values as more likely to come about than any substantial change in the opposite direction. There is, of course, an ample supply of copper on which increasing consumption can draw, but it is doubtful whether this can be done without an increase in price consequent on high cost producers coming into action. Current quotations :—*Cash* : Tuesday, £66 17s. 6d.; Wednesday, £66 12s. 6d.; Monday, £67 7s. 6d.; Tuesday, £67 5s.; Wednesday, £66 12s. 6d. *Three Months* : Tuesday, £67 17s. 6d.; Wednesday, £67 15s.; Monday, £68 10s.; Tuesday, £68 7s. 6d.; Wednesday, £67 15s.

Tin.—Movements in the standard metal have naturally been affected by after-holiday influences, but the tone throughout continues firm, with an entire absence of selling pressure, which will ensure a stable position for the time being. There is still uncertainty, however, as to the extent and effect of foreign competition in the tinplate industry. Moreover, a number of tinplate works in South Wales are either idle or on restricted production, but manufacturers expect rather more demand in the near future, when industrial activity is resumed. There is an entire absence of selling pressure, and as tin producers expect tinplate manufacturers to buy more freely in the New Year, they are holding for higher figures for later delivery. The statistical position is in favour of holders of tin. It is also regarded as probable that there will be more American demand. Current quotations :—*Cash* : Tuesday, £267 10s.; Wednesday, £268 15s.; Monday, £271 10s.; Tuesday, £272; Wednesday, £269 15s., *Three Months* : Tuesday, £271; Wednesday, £272; Monday, £274 15s.; Tuesday, £275 5s.; Wednesday, £273.

Spelter.—The market for this metal continues firm with a good deal of speculative activity and buying from consumers, due to the good statistical position of the commodity and anticipations of a bigger demand next year. Zinc has not risen in unison with lead and other non-ferrous metal, and may go higher later on Current quotations :—*Ordinary* : Tuesday, £38 10s.; Wednesday, £38 12s. 6d.; Monday, £39; Tuesday, £39 5s.; Wednesday, £39.

Lead.—The outlook in the market for foreign pig may be regarded as fairly favourable to future developments, buyers now having to pay heavily for prompt deliveries under the pressure of demand on Continental account. Within the last four months the quantities received from abroad amounted to fully 92,500 tons, a monthly average of over 23,000 tons, which should have been at least sufficient to meet all needs for home use and re-export combined, but evidently surplus parcels are held in strong hands. Current quotations :—*Soft foreign (prompt)* : Tuesday, £43 5s.; Wednesday, £43 12s. 6d.; Monday, £43 17s. 6d.; Tuesday, £44; Wednesday, £43 7s. 6d.

High Tensile Cast Iron.

Mr. Arthur Marks, the author of a Paper bearing the above title, and published in our last issue, points out that the "recent lecture at the London Branch" was meant to refer to his own lecture, "The Manufacture of Pearlitic Cast Iron for High-Temperature Work," which appeared in our issue of May 15, 1924, and not Mr. Hurst's lecture on "Pearlitic Cast Iron," which appeared on October 16, 1924.

Rails for the Soviet Union.—The Soviet Commissariat of Ways and Communications has fixed at 100,250 tons the quantity of rails to be ordered during the year 1924-25, against 58,000 tons last year. The board of the Glavmetall has decided to divide the order between the southern and the Ural trusts, the Yugostal supplying 52,000 tons and the Nadezhdinski combine 48,250 tons.